Effects of space allocation within a deep-bedded finishing system on pig growth performance, fatty acid composition and pork quality

Brenda S. Patton  
*Iowa State University*

Elisabeth J. Huff-Lonergan  
*Iowa State University*, elonerga@iastate.edu

Mark S. Honeyman  
*Iowa State University*, honeyman@iastate.edu

Brian J. Kerr  
*United States Department of Agriculture*

Steven M. Lonergan  
*Iowa State University*, slonerga@iastate.edu

Follow this and additional works at: [http://lib.dr.iastate.edu/ans_pubs](http://lib.dr.iastate.edu/ans_pubs)

Part of the Agriculture Commons, and the Meat Science Commons

The complete bibliographic information for this item can be found at [http://lib.dr.iastate.edu/ans_pubs/39](http://lib.dr.iastate.edu/ans_pubs/39). For information on how to cite this item, please visit [http://lib.dr.iastate.edu/howtocite.html](http://lib.dr.iastate.edu/howtocite.html).

This Article is brought to you for free and open access by the Animal Science at Iowa State University Digital Repository. It has been accepted for inclusion in Animal Science Publications by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
Effects of space allocation within a deep-bedded finishing system on pig growth performance, fatty acid composition and pork quality

Abstract
The objectives of the current study were to determine the degree to which space allocation in a deep-bedded system influences swine performance and pork quality. The deep-bedded method employed was hoop structures, which are large, tent-like shelters with cornstalks or straw for bedding. One hundred gilts ranging in weight from 59 to 71 kg were randomly assigned to treatments of low (0.70 m² per pig, \(n = 50\)) or high (1.13 m² per pig, \(n = 50\)) space allocation. During the 45-day experimental period, gilts were ad libitum fed a two-phase diet. Six gilts per treatment were used for carcass composition and pork quality evaluation for each replication. Five replications were conducted over a period of 4 months. Pigs finished with greater space allocation had smaller longissimus muscle area and produced pork that appeared to be darker. Variations in fatty acid composition and lipid percentage of subcutaneous adipose and longissimus dorsi muscle were observed when space allocation was changed within hoop structures. Less space resulted in greater proportion of lipid present as polyunsaturated fatty acids. Greater space allocation resulted in lower total lipid in subcutaneous pork adipose tissue. Space allocation did not affect fat firmness. Replications spanned the months of August to November, with temperatures ranging from 32°C to −2°C within the hoop structure. As environmental temperature declined, the proportion of monounsaturated fatty acids increased. Providing more space during finishing in these systems had only a small affect on pig growth and pork quality. Variations observed from replication to replication at fluctuating temperatures provide insight to seasonal differences in growth and adipose tissue composition and firmness. Therefore, finishing pigs in these systems may lead to seasonal variation in lipid composition.

Keywords
Pork composition, Pork quality, Stocking density

Disciplines
Agriculture | Animal Sciences | Meat Science

Comments
Effects of space allocation within a deep-bedded finishing system on pig growth performance, fatty acid composition and pork quality

B. S. Patton¹, E. Huff-Lonergan¹, M. S. Honeyman¹, B. J. Kerr² and S. M. Lonergan¹

¹Department of Animal Science, Iowa State University, Ames, IA 50011, USA; ²USDA-ARS- Swine Odor and Manure Management Research Unit, Ames, IA 50011, USA

(Received 12 April 2007; Accepted 17 October 2007)

The objectives of the current study were to determine the degree to which space allocation in a deep-bedded system influences swine performance and pork quality. The deep-bedded method employed was hoop structures, which are large, tent-like shelters with cornstalks or straw for bedding. One hundred gilts ranging in weight from 59 to 71 kg were randomly assigned to treatments of low (0.70 m² per pig, n = 50) or high (1.13 m² per pig, n = 50) space allocation. During the 45-day experimental period, gilts were ad libitum fed a two-phase diet. Six gilts per treatment were used for carcass composition and pork quality evaluation for each replication. Five replications were conducted over a period of 4 months. Pigs finished with greater space allocation had smaller longissimus muscle area and produced pork that appeared to be darker. Variations in fatty acid composition and lipid percentage of subcutaneous adipose and longissimus dorsi muscle were observed when space allocation was changed within hoop structures. Less space resulted in greater proportion of lipid present as polyunsaturated fatty acids. Greater space allocation resulted in lower total lipid in subcutaneous pork adipose tissue. Space allocation did not affect fat firmness. Replications spanned the months of August to November, with temperatures ranging from 32°C to −2°C within the hoop structure. As environmental temperature declined, the proportion of monounsaturated fatty acids increased. Providing more space during finishing in these systems had only a small affect on pig growth and pork quality. Variations observed from replication to replication at fluctuating temperatures provide insight to seasonal differences in growth and adipose tissue composition and firmness. Therefore, finishing pigs in these systems may lead to seasonal variation in lipid composition.

Keywords: pork composition, pork quality, stocking density

Introduction

Increased potential for niche marketing and a growing demand for improvement in pork quality have led to the development of alternative pig production systems (Wheatley, 2003; Millet et al., 2005). Alternatively managed systems differ from intensive systems in that pigs typically have more space to freely move about and have access to either pasture or deep bedding (Honeyman, 1996). These characteristics are brought about by variations in housing style, stocking density, floor type and provision of bedding or other types of environmental enrichment. Improvements in perceived welfare of pigs have driven alternative production systems to allocate larger space during rearing and finishing compared with confinement systems (Lyons et al., 1995).

Allocating different amounts of space to pigs during finishing influences social interactions (Turner et al., 2000; Schmolke et al., 2004) and growth performance potential (Hyun et al., 1998). Reduced space allocation has been shown to result in increases in observed abnormal behaviours and levels of aggression (Bryant and Ewbank, 1974; Randolph et al., 1981). One study reported that increasing stocking space from 0.40 to 0.63 m² per pig in deep-bedded finishers resulted in higher average daily feed intake (ADFI) and lower gain : feed ratio, with no difference in average daily gain (ADG) between the two treatment groups (Turner et al., 2000). Compared with other environmental stressors, reducing space allowance has been shown to decrease ADFI by 6.0% and feed efficiency by 10% (Hyun et al., 1998). In addition, changing space allocation during finishing may have profound effects on fatty acid composition, even when diet is standardised due...
to deviations in feed intake and feed utilisation (Nürnberg et al., 1998).

The components of meat quality influenced by fatty acids are adipose tissue firmness (hardness), shelf-life (lipid and pigment oxidation) and flavour. Higher levels of unsaturation will lead to softer, less-firm fat (Wood et al., 2007). Since soft fat is associated with greater percentage of unsaturated fatty acids, it is associated with a product with less shelf stability with regard to flavour stability. In Japan, soft fat is subjectively evaluated and can be a cause for downgrading a pork carcass (Irie et al., 1983). Sensory analysis has also shown that increased levels of unsaturated fatty acids in pork are negatively observed by pork consumers (Kouba et al., 2003) due to the propensity of unsaturated fatty acids to oxidise, leading to the development of rancidity during storage or retail display.

The standard stocking density commonly implemented in most confinement or all-in all-out systems is 0.72 to 0.90 m² per pig from 68 to 115 kg (NCR-89, 1993). There is no evidence that a space allowance of more than 0.93 m² per pig leads to improved performance and health of pigs (NCR-89, 1993; Gentry et al., 2002a; Hoy, 2004). In relation to common confinement systems, allocating more than 0.93 m² per pig may be improbable due to structural dimensions and finishing-group size. However, in alternative pig production systems in which an increased area such as pasture or a deep-bedded semi-outdoor structure is utilised, space may not be a limiting factor. Furthermore, allocating more space during finishing has been shown to affect behaviour and post mortem metabolism (Beattie et al., 2000; Klontz et al., 2001), which may lead to differences in ultimate pork quality. Although several studies have reported increased acceptability of pork from pigs finished in systems that allocate more space (Gentry et al., 2002a and 2002b; Estevez et al., 2003), these experiments are mainly comparisons of increased stocking density as well as comparisons of indoor and alternative or outdoor production systems. Research linking pork quality with varying stocking rates within certain alternative production systems is limited.

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

### Material and methods

**Animals**
The Iowa State University Institutional Animal Care and Use Committee approved use of animals for the described experiments. At 4 months of age, five groups of 100 gilts were weighed into allotment blocks by weight. From those weight blocks, gilts ranging in weight from 59 to 71 kg were randomly assigned to treatments of either low (0.70 m² per pig, n = 50) or high (1.13 m² per pig, n = 50) space allocation. Gilts were transported to the Iowa State University Western Research Farm, Castana, IA. The alternative housing method employed in the current study was the use of hoop structures, which are tent-like shelters with cornstalks or straw for bedding (Honeyman and Harmon, 2003). Gilts were ad libitum fed a two-phase diet (Table 1) for a period of 45 days. Six gilts per pen were selected for slaughter, carcass composition and meat quality evaluation. All pigs were transported to a distance of 200 km prior to delivery to the ISU Meat Laboratory for processing.

**Growth and performance**
Initial, 21- and 45-day body weights, and slaughter weight were obtained for each pig. ADG (g/day), feed conversion (G:F) and shrink (%) during transport and lairage were calculated for each pig.

**Slaughter and sample collection**
Feed was removed 18 h prior to slaughter. Gilts were randomly assigned to a process order and subsequently electrically stunned. After exsanguinations via jugular depletion, carcasses were eviscerated, washed and chilled. Carcasses were placed in a 0°C cooler and chilled for 24 h. After 24 h, carcasses were ribbed at the 10th–11th rib interface for carcass composition and pork quality evaluation.

**Carcass composition and quality**
Temperature and pH measurements were taken by a penetration probe at 1, 6 and 24 h post mortem on right-side loins using a Hanna 9025 pH/ORP meter (Hanna Instruments, Woonsocket, RI, USA). The pH probe was calibrated with temperature at each time period using two buffers (pH 4.2 and 7.10). Calibration was monitored after

### Table 1 Description of nutritional rations fed to gilts during the finishing period, as-is basis

<table>
<thead>
<tr>
<th>Ingredient, %</th>
<th>91 to 101 kg</th>
<th>101 to 113 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>81.95</td>
<td>83.95</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>12.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Soybean hulls</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>Vitamin + mineral premix&lt;sup&gt;1&lt;/sup&gt;</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>Soybean oil</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>L-lysine HCL</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

<sup>1</sup>Vitamin + mineral premix contained phytase.

<sup>2</sup>Calculated composition based on NRC (1998) values.
Space allocation affects pork quality

each carcass. Carcasses were ribbed between the 10th and
11th ribs and allowed to bloom for approximately 45 min.
Loins were assigned a score for colour firmness, wetness
and marbling while a trained panel \( n = 2 \) was used to
determine a colour score \( 1 = \) pale, \( 6 = \) dark \) for each loin
eye (National Pork Board, 2000). Firmness and wetness
were evaluated on a three-point scale \( 1 = \) soft and wet, \( 3 = \) firm and dry \).
Marbling values were based on National Pork Board standards.
Tenth rib loin depth and loin eye area
were measured and recorded with percentage fat-free lean
as calculated using the National Pork Board fat-free lean
percentage calculation (National Pork Board, 2000).

Hunter \( L^* \) (light–dark), \( a^* \) (red–green) and \( b^* \) (yellow–blue) values were determined at 1 day
post mortem on 2.54-cm-thick chops. Samples were allowed to bloom for
1 h at room temperature and were analysed on a calibrated
Hunter Labscan colorimeter (Hunter Associates Laboratories
Inc., Reston, VA, USA). A CIE D65 10° standard observer
and a 1.27 cm viewing port were used to obtain three-colour
measurements on each of three chops. All nine
colour measurements were used to determine an average
colour score for each loin. Drip loss was determined using
2.54-cm-thick boneless chops (two per loin) by a method
similar to Lonergan et al. (2001). Purge loss was measured
using Tukey’s test with an \( \alpha = 0.05 \).

Adipose tissue firmness

Adipose samples were cut into \( 5 \times 3 \)-cm squares and
analysed for firmness using a method modified from Nishioa
and Irie (2005). Samples were evaluated using TA-XT2
texture analyser (Texture Technologies, Scarsdale, NY, USA)
with a 0.25" diameter ball-shaped probe. Sample height
was noted by the testing machine, and the probe was
driven downward at 2 mm/s to compress the sample to
20% of the sample height.

Statistical analysis

The influence of space allocation on performance pork
quality and adipose tissue attributes were analysed using
general linear model (GLM) procedures of Statistical
Analysis Systems Institute Inc. (Cary, NC, USA). The experi-
mental model included main effects of space allocation
and replication and their interaction as independent
variables. Pairwise comparisons of means were carried out
using Tukey’s test with an \( \alpha = 0.05 \).

Results

Allocating larger amounts of space did not influence ADG or
feed conversion ratios (Table 2). Initial weight, slaughter
weight and dressing percentage did not vary by treatment,
and space allocation did not affect backfat thickness at the
10th or last rib. Pigs finished with greater space allocation
had a smaller loin eye area. Specific treatment-by-replication
interactions were noted for slaughter weight, carcass
weight and fat-free lean percentage.

Space allocation within hoop structures in this experi-
ment had minimal influence on fresh-pork quality (Table 3).
Temperature and pH decline did not differ between the two
treatment groups. Space allocation did not affect pork loin
marbling, firmness or wetness. Pigs finished with greater
space allocation produced pork appearing darker than pigs
stocked at higher rates; however, there were no measurable
differences between Hunter \( L^* \), \( a^* \) or \( b^* \) between pigs
raised in the two space allocations. Pork from pigs finished
in different stocking allocations did not differ in drip or
purge loss. Table 4 presents cooking loss and Star Probe
measurements taken at 24 and 120 h of ageing. There were
no differences between treatment groups on any cooked-
pork quality attribute. Adipose firmness did not consistently
differ due to treatment.

Space allocation variation altered the fatty acid composi-
tion of inner layer of adipose tissues as well as lean tissues
(Tables 5 and 6). Pigs allotted more space produced adipose
with greater proportion of myristic acid and lower proportion
of linoleic acid in adipose tissues. These differences in
concentration corresponded to differences in the proportion
of saturated and polyunsaturated fatty acids (PUFA). Lipid
percentage in adipose tissue was greater in pork from pigs allotted more space during finishing. Adipose tissue from pigs allotted less space contained a greater proportion of saturated and PUFA than adipose tissue from pigs allotted more space. Adipose tissue from pigs allotted less space also contained a lower proportion of palmitoleic acid.
Fatty acid profiles of each tissue varied by experiment replication. As noted, replications spanned the months of August to November 2004, with temperatures ranging from 32°C to -2°C within the hoop structure (Figure 1). Figure 2 presents the variations in adipose tissue total saturated (SFA), monounsaturated fatty acids (MUFA) and PUFA by replication group of the experiment. Comparing these fluctuations to temperature fluctuations (Figure 1), a decline in ambient temperature corresponded to decreases in total saturation and polyunsaturation and increases in the monounsaturation of both tissues.

**Discussion**

Adjusting the space allocation for pigs during rearing and finishing has been widely investigated (Pearce and Paterson, 1993; McGlone and Newby, 1994; Hoy, 2004). Recent shifts in pork production systems favour increased space per pig, based on perceived benefit and health of the animal (Millet et al., 2005). Current research exploring strategies in alternative production systems has revealed that increasing space allocation stimulates foraging or explorative behaviour in pigs, thereby increasing favourable interactions and lowers stress susceptibility among pigs (Guy et al., 2002; Olsen et al., 2002; Van de Weerd et al., 2003). Increasing space allocation also influences growth and carcass composition characteristics, stimulating improved growth performance and carcass composition (Gentry et al., 2002b; Honeyman and Harmon, 2003). Reduction in stress may promote an increase in growth and performance of pigs. These differences in behaviour during finishing could influence the physiological and behavioural

### Table 4 Effect of space allocation within hoops on cooked pork quality attributes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Space allocation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low^1</td>
<td>High^1</td>
</tr>
<tr>
<td>Star Probe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 h (kg)^2</td>
<td>6.69</td>
<td>6.74</td>
</tr>
<tr>
<td>120 h (kg)</td>
<td>6.96</td>
<td>6.83</td>
</tr>
<tr>
<td>Cooking loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 h (%)^3</td>
<td>29.89</td>
<td>32.54</td>
</tr>
<tr>
<td>120 h (%)</td>
<td>31.65</td>
<td>30.74</td>
</tr>
</tbody>
</table>

^1Low = 0.70 m²/pig; high = 1.13 m²/pig.
^2Presented as least squares means.
^3Significance: **P < 0.05; ***P < 0.01; NS: P > 0.05; L v. H = space allocation significance, low v. high = replication group of experiment significance; TRT $\times$ Rep = treatment-by-group interaction significance.
^4Star probe texture evaluated at 24 and 120 h ageing periods using TA-XT2 texture analyser with probe driven downward at 2 mm/s to 20% of sample height. Peak force exerted (kg) is presented.
^5Cooking loss calculated as (raw chop weight – cooked chop weight)/(raw chop weight) $\times$ 100.

### Table 5 Effect of space allocation within hoops on fatty acid composition and total lipid concentration of adipose tissue^2

<table>
<thead>
<tr>
<th>Fatty acid</th>
<th>Formula</th>
<th>Space allocation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low^1</td>
<td>High^1</td>
</tr>
<tr>
<td>Myristic acid</td>
<td>C14:0</td>
<td>1.88</td>
<td>3.09</td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>C16:0</td>
<td>20.25</td>
<td>15.01</td>
</tr>
<tr>
<td>Palmitoleic acid</td>
<td>C16:1 n-7</td>
<td>5.50</td>
<td>10.22</td>
</tr>
<tr>
<td>Heptadecanoic acid</td>
<td>C17:0</td>
<td>0.93</td>
<td>0.83</td>
</tr>
<tr>
<td>Heptadecenoic acid</td>
<td>C17:1 n-10</td>
<td>0.73</td>
<td>1.14</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>C18:0</td>
<td>11.31</td>
<td>11.59</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>C18:1 n-9</td>
<td>39.96</td>
<td>39.33</td>
</tr>
<tr>
<td>trans-Vaccenic acid</td>
<td>C18:1 n-7</td>
<td>0.76</td>
<td>1.49</td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>C18:2 n-6</td>
<td>15.38</td>
<td>12.74</td>
</tr>
<tr>
<td>α-Linolenic acid</td>
<td>C18:3 n-3</td>
<td>1.00</td>
<td>0.96</td>
</tr>
<tr>
<td>Arachidic acid</td>
<td>C20:0</td>
<td>0.67</td>
<td>1.74</td>
</tr>
<tr>
<td>Arachidonolic acid</td>
<td>C20:4 n-6</td>
<td>0.63</td>
<td>0.73</td>
</tr>
<tr>
<td>Eicosapentaenoic acid</td>
<td>C20:5 n-3</td>
<td>0.46</td>
<td>0.51</td>
</tr>
<tr>
<td>Behenic acid</td>
<td>C22:0</td>
<td>0.31</td>
<td>0.32</td>
</tr>
<tr>
<td>Docosapentaenoic acid</td>
<td>C22:5 n-3</td>
<td>0.18</td>
<td>0.19</td>
</tr>
<tr>
<td>Docosahexaenoic acid</td>
<td>C22:6 n-3</td>
<td>0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>Total saturated</td>
<td>34.06</td>
<td>32.63</td>
<td>0.82</td>
</tr>
<tr>
<td>Total MUFA</td>
<td>46.95</td>
<td>52.18</td>
<td>0.14</td>
</tr>
<tr>
<td>Total PUFA</td>
<td>17.54</td>
<td>15.24</td>
<td>0.88</td>
</tr>
<tr>
<td>% Lipid</td>
<td>81.55</td>
<td>85.52</td>
<td>1.89</td>
</tr>
</tbody>
</table>

Abbreviations are: MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.
^1Analysis done on inner layer of backfat tissue.
^2Low = 0.70 m²/pig; high = 1.13 m²/pig.
^3Presented as least squares means.
^4Significance: **P < 0.05; ***P < 0.01; NS: P > 0.05; L v. H = space allocation significance, low v. high = replication group of experiment significance; TRT $\times$ Rep = treatment-by-group interaction significance.
responses of pigs in the period before slaughter, which have been shown to affect peri mortem muscle metabolism and thereby pork quality (Tarrant, 1989; Cassens, 2000).

In this study, no differences were observed in growth and performance of pigs finished in hoop structures with greater space allocation (Table 2). The current results differed from those reported by Honeyman and Harmon (2003) where pigs were allotted densities of 1.11 m² per pig in hoops and 0.74 m² per pig in confinement over winter and summer seasons. In the winter portion of the trial, hoop-fed pigs had similar growth performance but had greater ADFIs and less efficiency of lean gain than confinement-fed pigs. In the summer portion, hoop-fed pigs had greater ADG but had similar ADFIs and feed efficiency rates compared with confinement-fed pigs (Honeyman and Harmon, 2003), which led those authors to conclude that the increased space allocation (1.11 m² per pig) may have improved performance of pigs finished in hoop structures, but these improvements were seasonally inconsistent. Clearly, other variables may contribute to the observed differences such as group size, bedding type and ambient temperature.

Figure 1 shows the average, high and low temperatures within the hoop structures over the span of the experiment. Fluctuations in average, high and low temperatures (°C) were recorded over the five repetitions of the experiment (August to November). Temperatures were recorded every minute using a HOBO Pro Series™ temperature recorder. Temperatures are recorded as averages of triplicate measures taken throughout the systems. ▲ = high, ● = average, □ = low.

Abnormal Temperature Fluctuations

Figure 1 Ambient temperature fluctuations within hoop structures. Fluctuations in average, high and low temperatures (°C) were recorded over the five repetitions of the experiment (August to November). Temperatures were recorded every minute using a HOBO Pro Series™ temperature recorder. Temperatures are recorded as averages of triplicate measures taken throughout the systems. ▲ = high, ● = average, □ = low.

Table 6 Effect of space allocation within hoops on fatty acid composition and total lipid concentration of lean tissue

<table>
<thead>
<tr>
<th>Fatty acid</th>
<th>Formula</th>
<th>Space allocation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low a</td>
<td>High b</td>
</tr>
<tr>
<td>Myristic acid</td>
<td>C14:0</td>
<td>6.70</td>
<td>5.78</td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>C16:0</td>
<td>21.15</td>
<td>24.40</td>
</tr>
<tr>
<td>Palmitoleic acid</td>
<td>C16:1 n-7</td>
<td>4.08</td>
<td>4.08</td>
</tr>
<tr>
<td>Heptadecanoic acid</td>
<td>C17:0</td>
<td>0.90</td>
<td>1.00</td>
</tr>
<tr>
<td>Heptadecenoic acid</td>
<td>C17:1 n-10</td>
<td>0.92</td>
<td>0.98</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>C18:0</td>
<td>11.45</td>
<td>12.25</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>C18:1 n-9</td>
<td>28.41</td>
<td>29.32</td>
</tr>
<tr>
<td>trans-Vaccenic acid</td>
<td>C18:1 n-7</td>
<td>3.83</td>
<td>3.10</td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>C18:2 n-6</td>
<td>16.69</td>
<td>13.12</td>
</tr>
<tr>
<td>Arachidonic acid</td>
<td>C20:4 n-6</td>
<td>5.87</td>
<td>5.97</td>
</tr>
<tr>
<td>Total Saturated</td>
<td></td>
<td>40.19</td>
<td>41.14</td>
</tr>
<tr>
<td>Total MUFA</td>
<td></td>
<td>37.24</td>
<td>37.33</td>
</tr>
<tr>
<td>Total PUFA</td>
<td></td>
<td>22.58</td>
<td>20.54</td>
</tr>
</tbody>
</table>

Abbreviations are: MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

aAnalysis done on lean portion of longissimus dorsi.

bLow = 0.70 m²/pig; high = 1.13 m²/pig.

Significance: **P < 0.05; ***P < 0.01; NS: P > 0.05; L v. H = space allocation significance, low v. high = replication group of experiment significance; TRT x Rep = treatment-by-group interaction significance.

Table 6 Effect of space allocation within hoops on fatty acid composition and total lipid concentration of lean tissue

Abbreviations are: MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

Patton, Huff-Lonergan, Honeyman, Kerr and Lonergan

476
observed a higher water-holding capacity in pork chops from pigs produced in an ‘enriched environment’. The current study varied from that study in housing style, as the current experiment was conducted in semi-outdoor hoop structures while Klont et al. (2001) conducted it in a confinement system. Texture attributes as well as cooking loss did not vary between treatments (Table 4). Our results are similar to those of Stern et al. (2003), who showed that technological meat quality traits such as cooking loss and Warner–Bratzler shear force did not differ between lower and higher stocked pigs finished in an outdoor, free-range system.

Fatty acid composition of lean and adipose tissue was altered by space allocation (Tables 5 and 6). Adipose tissue from pigs provided less space was more saturated and was composed of higher percentages of PUFA. These results are interesting in that there were no differences in feed intake or feed efficiency between the two groups. Variations in fatty acid were observed between replications of the experiment. Lebret et al. (2002) reported that a decrease in outdoor environmental temperature from 24°C to 17°C during the finishing period of pig led to higher total MUFA, SFA and PUFA contents in the inner layer of adipose tissue. Figure 2a–c presents the variations in adipose tissue SFA, MUFA and PUFA by replication group of the experiment. Comparing these fluctuations to temperature fluctuations (Figure 1), a decline in ambient temperature corresponded to decreases in total saturation and polyunsaturation of the adipose tissue. In agreement with Lebret et al. (2002), a subsequent increase in monounsaturation was measured as temperature decreased. Therefore, replication responses and treatment effects might have been dictated by temperature differences, leading to differences in fatty acid profile. Variations in ambient temperature and its subsequent affect on fatty acid profile is an interesting observation and merits continued investigation.

Dietary fat and amount of deposited fat are major factors influencing the fatty acid composition of adipose lipids (Nürnberg et al., 1998). This was apparent in the current study, as diets were standardised, but treatment groups did differ in total percentage lipid within the inner layer of adipose tissue (Table 4). Pigs with greater space allocation had higher (85.52% v. 81.55%) total lipid in the adipose tissue than pigs reared with less space. Paralleling these differences, as noted above, was an increase in PUFA incorporation in pigs with less space. It has been established that when tissue lipid content is reduced, the proportion of unsaturated phospholipids is higher, driving an increase in overall PUFA content (Bee, 2002; Bee et al., 2004).

Conclusions
The results showed that allocating more space during finishing in hoop structures did not affect pig performance or pork quality. Deposition variations in adipose tissue became more prominent as temperatures decreased. Utilisation of systems that do not control the environment may result in seasonal variations in pork composition.

Acknowledgements
Mention of a trade name, proprietary product or specific equipment does not constitute a guarantee or warranty by the USDA or Iowa State University and does not imply approval to the exclusion of other products that may be suitable. This project was supported by Hatch Act and State of Iowa funds, USDA Special Grants and the Leopold Center for Sustainable Agriculture. The authors recognise the significant efforts of the Iowa State University Western Research Farm for animal care.
The authors also recognise the technical support provided by Randall Petersohn and the Iowa State University Meat Laboratory.

References


