K-STATE Research and Extension

Effects of Space Allowance and Marketing Strategy on Growth Performance of Pigs Raised to Heavy Market Weights [1]

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Summary

A total of 976 pigs (PIC 327 × L42, initially 48.6 ± 3.4 lb body weight [BW]) were used in a 160-d growth study to determine the influence of space allowance and marketing strategy on growth performance of pigs raised to heavy market weights. Pens were blocked by location within the barn and allotted to 1 of 6 dietary treatments with 8 pens per treatment. The first four treatments reduced space allowance per pig via initial pen stocking density and had only one final marketing event. These four treatments were: 14 pigs/pen (12.7 ft²/pig), 17 pigs/pen (10.4 ft²/pig), 20 pigs/pen (8.8 ft²/pig), 23 pigs/pen (7.7 ft²/pig). The fifth treatment began with 25 pigs/pen (7.1 ft²/pig) and the heaviest 3 pigs/pen were removed on d 93, then on d 122 they were topped again to a common inventory of 20 pigs/pen, and on d 147 topped to a common pen inventory of 17 pigs/pen. The sixth treatment began with 23 pigs/pen (7.7 ft²/pig) and was topped to a common inventory of 20 pigs/pen on d 108 and finally topped again to a common inventory of 17 pigs/pen on d 147. Average daily gain (ADG), average daily feed intake (ADFI), and final BW decreased (linear, $P < 0.001$) during the overall experimental period (d 0 to 160) as space allowance decreased. When comparing treatments with multiple marketing events to those with similar initial stocking density (23 pigs per pen), there was no evidence for differences ($P > 0.05$) for overall ADG or ADFI; however, overall feed efficiency was improved ($P < 0.05$) for pigs initially stocked at 7.1 ft²/pig and marketed four times compared to both treatments that initially allowed 7.7 ft²/pig, regardless of marketing structure. Additionally, overall F/G was improved for pigs that began at 7.7 ft²/pig and had 3 marketing events compared to the treatment that also began at 7.7 ft²/pig but had only a single marketing event. Once the marketing events began on d 93, ADG and F/G were improved

($P < 0.05$) for the remaining pigs in the pen for the rest of the trial (d 93 to 160) for both multiple marketing treatments, compared to the 7.7 ft²/pig allowance where all pigs were marketed together at the end of the trial. These findings are consistent with others that evaluate more traditional market weights where growth performance is reduced prior to pigs reaching their k-value, and align with recent models that predict the rate of change in growth performance as pigs are allowed more spacing during the finishing period. Similarly, it appears that pigs respond to removal of the heaviest pigs in the pen before market with the remaining pigs in the pen demonstrating compensatory gain after being provided with increased space. These results indicate that decreasing space allowance for heavy weight pigs reduced growth, intake, and final BW, although use of pig removals prior to final marketing may allow producers to maximize number of pigs marketed while balancing reduced growth performance generally accompanied with increased stocking density. Additionally, growth continued to increase until approximately 340 lb, indicating a potential opportunity for swine producers to capture lean growth at much heavier weights than previously predicted.

Introduction

Space requirements for growing pigs are typically established by using the k-value determined by Gonyou et al.[5] They estimated that every decrease in k less than 0.0336 resulted in decreased average daily gain (ADG) and average daily feed intake (ADFI) for grow-finish pigs reared on fully-slatted flooring. While Flohr et al.[6] concluded the k-value established by Gonyou et al.[5] was a valid predictor of the effect of space allowance on growth performance for pigs raised to 310 lb, others demonstrated the k-value may underestimate the space allowance needed before growth performance is reduced.[7,8]

In addition to adjusting the initial stocking density of a pen, topping is another strategy that producers implement to provide finishing pigs increased floor space. This method involves the removal of one or more of the heaviest pigs in the pen, prior to the final marketing event. This additional space allows the remaining pigs to reach the target market weight and provides more consistent weights at the packing plant, resulting in fewer packer discounts for variability.[9]

[5]Gonyou, H., M. Brumm, E. Bush, J. Deen, S. Edwards, T. Fangman, J. McGlone, M. Meunier-Salaun, R. Morrison, and H. Spoolder. 2006. Application of broken-line analysis to assess floor space requirements of nursery and grower-finisher pigs expressed on an allometric basis. Journal of animal science 84(1):229-235.

[6]Flohr, J. R., M. D. Tokach, J. M. DeRouchey, J. C. Woodworth, R. D. Goodband, and S. S. Dritz. 2016. Evaluating the removal of pigs from a group and subsequent floor space allowance on the growth performance of heavy-weight finishing pigs. Journal of animal science 94(10):4388-4400.

[7]Potter, M., M. D. Tokach, J. M. DeRouchey, R. D. Goodband, J. L. Nelssen, and S. S. Dritz. 2010. Effects of increasing stocking density on finishing pig performance. Kansas Agricultural Experiment Station Research Reports (10):216-222.

[8]Thomas, L., R. Goodband, J. Woodworth, M. Tokach, J. DeRouchey, and S. Dritz. 2017. Effects of space allocation on finishing pig growth performance and carcass characteristics. Translational Animal Science 1(3):351-357.

[9]Jacela, J., M. D. Tokach, J. M. DeRouchey, R. D. Goodband, J. L. Nelssen, and S. S. Dritz. 2009. Economic impact of removing pigs before marketing on the remaining pigs' growth performance. Kansas Agricultural Experiment Station Research Reports (10):262-269.

In the United States, average pig market weight increased over the past several years and averaged 282 lb during 2017.[10] It is estimated this trend will continue over the next several years. Wu et al.[11] reviewed the current understanding of raising pigs to heavier market weights and identified animal housing and identifying optimal floor space requirements as critical needs for future research. Therefore, the objective of this study was to understand space requirements of pigs raised to 360 lb by either providing increasing floor space allowance via decreased initial stocking density or by implementing traditional topping strategies.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The trial was conducted at a commercial research facility owned and operated by Holden Farms, Inc. (Northfield, MN). The barn was double-curtain sided with completely slatted concrete flooring and deep pits for manure storage. Each pen (10 × 18 ft) was equipped with adjustable gates and contained a 3-hole, dry feeder (Thorp Equipment, Inc., Thorp, WI) and a double-sided pan waterer. Feed additions were delivered and recorded using a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN).

A total of 976 pigs (PIC 327 × L42, initially 48.6 ± 3.4 lb BW) were used. Pen served as the experimental unit, and there were 8 replicate pens per treatment. Pens were blocked by location within the barn and allotted to 1 of 6 dietary treatments. The first four treatments (Table 1) consisted of increased initial stocking density and did not utilize topping strategies: 1) 14 pigs/pen (12.7 ft²/pig); 2) 17 pigs/pen (10.4 ft²/pig); 3) 20 pigs/pen (8.9 ft²/pig); and 4) 23 pigs/pen (7.7 ft²/pig). The fifth treatment began with 25 pigs/pen (7.1 ft²/pig) with 3 pigs/pen topped on d 93, then on d 122 pens were topped to a common inventory of 20 pigs/pen, and a final topping event occurred on d 147 to achieve a common pen inventory of 17 pigs/pen. The sixth treatment started with 23 pigs/pen (7.7 ft²/pig) and was topped to a common inventory of 20 pigs/pen on d 108 with a final topping event occurring on d 147 to reach a common inventory of 17 pigs/pen.

Pens of pigs were weighed and feed disappearance was measured on d 0, 13, 27, 41, 55, 69, 82, 93, 108, 122, 135, 147, and 160 to determine ADG, ADFI, and feed efficiency (F/G). An additional response criteria of adjusted F/G was calculated to adjust F/G to a common BW of 285 lb by using an adjustment of 0.0048 for every 1 lb difference in body weight. In the case of a pig removal due to illness or death, pen gates were adjusted to maintain the desired floor space allowance.

Pigs were given *ad libitum* access to feed and water throughout the study. Diets were corn- and soybean meal-based and included 30 to 40% corn dried distillers grains with solubles until the final dietary phase (Table 2). Diets were fed in 6 sequential phases from approximately 48 to 70, 70 to 120, 120 to 180, 180 to 230, 230 to 270, and 270 lb

[10]NASS. 2017. Agricultural Statistics. USDA. National Agricultural Statistics Service. U.S. Gov. Print. Office, Washington, DC.

[11]Wu, F., K. R. Vierck, J. M. DeRouchey, T. G. O'Quinn, M. D. Tokach, R. D. Goodband, S. S. Dritz, and J. C. Woodworth. 2017. A review of heavy weight market pigs: status of knowledge and future needs assessment. Translational Animal Science 1(1):1-15. doi: 10.2527/tas2016.0004

until the end of the study. Diets were formulated to meet or exceed NRC[12] requirement estimates for finishing pigs and contained 1.18, 1.03, 0.88, 0.78, 0.76, and 0.77% standardized ileal digestible (SID) lysine (Lys) in phases 1 through 6, respectively. All diets were fed in meal form and manufactured at a commercial feed mill (Blooming Prairie, MN).

Data were analyzed as a randomized complete block design using the PROC GLIMMIX procedure of SAS (version 9.4, SAS Institute, Inc., Cary, NC) with pen considered the experimental unit and location as blocking factor. Linear and quadratic contrasts were applied for the four treatments without topping strategies. The LSMEANS statement was used to separate the two topping strategies from each other and the treatment was stocked at 7.7 ft^2/pig with only one marketing event. These comparisons were utilized to understand differences between the multiple marketing treatments to the treatment with the most similar initial stocking density, as these three treatments are the most representative of industry floor space allowance and marketing strategies currently utilized. Results were considered significant at $P \leq 0.05$.

Results and Discussion
Reducing Floor Space via Initial Pen Inventory
The four treatments that utilized fixed pen inventories for the entire study were evaluated using linear and quadratic contrast statements (Table 3). As floor space allowance was decreased from 12.7 to 7.7 ft^2/pig, ADG was also reduced from d 0 to 93, d 108 to 122, d 122 to 135, and for the overall trial (linear, $P < 0.005$). However, there was no evidence for differences in ADG from d 93 to 108, d 135 to 147, or d 147 to 160 ($P > 0.145$). Average daily feed intake was decreased as floor space allowance was reduced from 12.7 to 7.7 ft^2/pig during all intermediate periods of the study and for the overall experiment (linear, $P < 0.026$). There was no evidence that decreasing floor space allowance from 12.7 to 7.7 ft^2/pig impacted F/G during any intermediate period or the overall trial ($P > 0.070$). There was no evidence for differences on d 0 BW ($P = 0.994$), yet BW was linearly decreased ($P < 0.008$) as floor space was reduced from 12.7 to 7.7 ft^2/pig on d 93, 108, 122, 135, 147, and 160. Overall adjusted F/G did not show evidence of linear or quadratic activity ($P > 0.053$).

Although removals were numerically increased with decreasing floor space, high variation resulted in no evidence ($P > 0.05$) for linear or quadratic differences in removals with the static inventory treatments. Furthermore, total weight gain was increased ($P = 0.001$) on a pen basis and decreased ($P = 0.001$) on a per pig basis as stocking density increased.

Adjusting Floor Space via Pig Removal
The treatments that incorporated multiple marketing events were evaluated in comparison with each other and to the treatment that was initially stocked at 7.7 ft^2/pig with only 1 marketing event. From d 0 to 93 where no marketing occurred, there was no evidence that ADG, ADFI, or F/G were different between the two treatments with multiple marketing events or compared to the pens stocked at 7.7. ft^2/pig ($P > 0.05$).

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[12]NRC. 2012. Nutrient requirements of swine. 11th rev. ed. Natl. Acad. Press, Washington, DC.

Similarly, from d 93 to 108, after pens originally stocked at 7.1 ft²/pig were topped for the first time, there was no evidence for differences in ADG or ADFI ($P > 0.05$) when comparing the two treatments with multiple marketing events to each other and to the treatment that allowed 7.7 ft²/pig with no marketing events yet. However, after the heaviest pigs were marketed from the pens initially stocked at 7.1 ft²/pig pens, these pigs demonstrated improved F/G compared to both treatments initially stocked at 7.7 ft²/pig ($P < 0.05$), regardless of marketing strategy, which were not different from each other ($P > 0.05$). Body weight on d 108 was increased ($P < 0.05$) for pigs initially allowed 7.7 ft²/pig but not marketed compared to those initially allowed 7.1 ft²/pig, but were not different ($P > 0.05$) from their counterparts allowed 7.7 ft²/pig with multiple marketing events. The treatments with multiple marketing events did not differ between each other for d 108 BW ($P > 0.05$).

The treatment originally stocked at 7.7 ft²/pig with 3 marketing events was topped on d 108, yet there was no evidence for differences in ADG, ADFI, or F/G from d 108 to 122 ($P > 0.05$).

The next marketing event occurred for the treatment initially allowed 7.1 ft²/pig which were marketed for the second time to 20 pigs/pen on d 122. From d 122 to 135, both treatments with multiple marketing events demonstrated increased ADG compared to the treatment that allowed 7.7 ft²/pig with only one marketing event at the end of the study ($P < 0.05$), yet they were not different from each other ($P > 0.05$). This response indicates that compensatory gain is occurring for the slower growing pigs remaining in the pen once they are provided with more space. There was no evidence ($P > 0.05$) that ADFI or F/G differed from d 122 to 135 for any of these comparisons.

There were no marketing events on d 135. However, pens initially stocked at 7.1 ft²/pig that had two marketing events thus far demonstrated increased ADG from d 135 to 147 compared to both treatments that began with 7.7 ft²/pig ($P < 0.05$), regardless of marketing strategy. Pens that began with 7.7 ft²/pig and had been marketed once up to this point also had increased ($P < 0.05$) ADG compared to their counterparts that were only to be marketed once at the end of the study. Although this response is not exhibited directly after the removal of the heaviest pigs for market, this compensatory gain appears to be due to the remaining pigs being allowed more space. For ADFI during this period, both treatments with multiple marketing events had increased ($P < 0.05$) ADFI compared to the treatment that began at 7.7 ft²/pig that had no pigs removed prior to the final marketing event, yet were not different from each other ($P > 0.05$). Feed efficiency was improved ($P < 0.05$) for pens of pigs that had been marketed twice and initially stocked at 7.1 ft²/pig, compared both to pens stocked at 7.7 ft²/pig that were either only marketed once at the end of the study and those marketed once up to this time point, which were not different from each other ($P > 0.05$).

The last marketing events occurred for both multiple marketing treatments on d 147, at which point both treatments had 17 pigs/pen remaining. From d 147 to 160, ADG and F/G did not differ ($P > 0.05$) between these multiple marketing treatments or compared to the treatment that allowed 7.7 ft²/pig with only one marketing event at the end of the study. Average daily feed intake was increased ($P < 0.05$) for pens of pigs stocked at 7.7 ft²/pig and marketed twice compared to their counterparts that were only

marketed at the end of the study, yet similar to the other multiple marketing treatment ($P > 0.05$). There was no evidence ($P > 0.05$) that pens of pigs allowed 7.7 ft²/pig with no previous marketing events had different ADFI than those allowed 7.1 ft²/pig but were marketed 3 times.

There was no evidence that overall ADG or ADFI differed between these three treatments ($P > 0.05$). Feed efficiency was improved ($P < 0.05$) for pigs initially stocked at 7.1 ft²/pig and marketed four times compared to both treatments that initially allowed 7.7 ft²/pig, regardless of marketing strategy. Additionally, F/G was improved for pigs that began at 7.7 ft²/pig and were marketed 3 times compared to the treatment that also began at 7.7 ft²/pig but was only marketed once at the end of the study.

There was no evidence that d 122, 135, 147, or final BW differed between these three treatments ($P > 0.05$). However, once the marketing began on d 93, ADG and F/G were improved ($P < 0.05$) for the remainder of the trial (d 93 to 160) for both multiple marketing treatments compared to the 7.7 ft²/pig allowance with only one marketing event at the end of the study, but were not different from each other ($P > 0.05$). This indicates that once marketing events began, the subsequent performance of remaining pigs in the pen was improved.

Removals and total weight gain per pen did not differ between these three treatments ($P > 0.05$). However, total weight gain per pig was greatest ($P < 0.05$) for pigs originally stocked at 7.7 ft²/pig with only one marketing event at the end of the study compared to both multiple marketing treatments. Furthermore, marketing three times with initial stocking density of 7.7 ft²/pig increased ($P < 0.05$) total weight gain per pig compared to marketing four times.

Body weight was used to calculate k-value for all weigh days (Table 4). According to Gonyou et al.,[5] a k-value less than 0.0336 results in decreased growth performance due to pigs being space-restricted. Interestingly, ADG from d 0 to 93 was decreased among static inventory treatments due to reduced feed intake with decreasing floor space allowance. This immediate impact was not anticipated given that all pigs were still greater than their k-value on d 93 with exception to the 7.7 ft²/pig treatment. Even at a final BW of 377 lb, pigs stocked at 14 pigs/pen remained greater than their k-value. The multiple marketing treatments were designed to raise the k-value after pigs were removed, generally bringing them greater than or close to the suggested k-value of 0.0366. These marketing events generally resulted in improved performance for the subsequent periods.

Flohr et al.[6] reviewed available literature to develop multivariate prediction equations to estimate ADG and ADFI as a function of BW and k-value. Increasing floor space among the static inventory treatments used in this experiment should yield a 7.8% improvement in ADG according to this prediction model. Our overall data shows an improvement of about 6.5% when increasing space from 7.7 to 12.7 ft²/pig. Similarly, the prediction equations from Flohr et al.[6] indicate that increasing this floor space allowance would improve ADFI by 6.3%, where the actual overall ADFI in this study improved by approximately 7.5% when pigs were allowed 12.7 ft²/pig vs. 7.7 ft²/pig. Lastly, the predicted improvement in feed efficiency was 1.4% and the actual improve-

ment was about 1.2%. Although the final body weights in this study exceed those used in developing the prediction model, these equations appear to be robust indicators of expected growth outcomes with increasing space allowance for pigs at heavy market weights.

When evaluating overall growth rates, it appears that the pigs used in this study had increasing ADG, albeit marginally, until approximately 340 lb BW before ADG started to decline. There was some variation within the ADG from this data set during the d 93 to 108 period as the commercial site received an acute health challenge, but it is clear from the remaining data that pigs recovered from this early challenge. Nevertheless, this continuous improvement in ADG far past typical market weights may be a result of improved genetic potential, especially the capacity to deposit lean tissue. Modern commercial pigs may have growth curves that plateau at later BW or d of age than those previously studied. This is a useful finding as it would be a very straightforward means of increasing the amount of pork produced. Contrary to ADG, the feed intake of these pigs was still increased up to 360 lb BW which is generally consistent with literature.[13] Lastly, although ADG continued to increase until late in the study, F/G became poorer as BW increased, which is also expected.

In conclusion, these results demonstrate that the impact of reducing floor space allowance for pigs raised to heavy market weights is seen as early as 230 lb, or before reaching the critical *k*-value. Furthermore, a pig removal strategy via multiple marketing events may provide producers a means to maximize stocking density while mediating reduced performance. This is a result of improved performance of the remaining pigs after the heaviest pigs are removed.

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[13]Shull, C. 2013. Modeling growth of pigs reared to heavy weights. Dissertation, University of Illinois at Urbana-Champaign.

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Table 1. Initial space allowance and removal strategy

Initial floor space, ft²:	12.7	10.4	8.8	7.7	7.1[2]	7.7[3]
Final floor space, ft²:	12.7	10.4	8.8	7.7	10.4	10.4
Initial pigs/pen:	14	17	20	23	25	23
Marketing events:	1	1	1	1	4	3
Removals						
d 93	---	---	---	---	3	---
d 108	---	---	---	---	---	To common inventory of 20
d 122	---	---	---	---	To common inventory of 20	---
d 147	---	---	---	---	To common inventory of 17	To common inventory of 17
d 160	------------------------------ all remaining pigs ------------------------------					

[1]A total of 976 finishing pigs (initially 48 ± 3.4 lb BW) were used in a 160-d experiment to evaluate the effects of pig space allowance and marketing strategy on finishing pigs raised to heavier weights.

[2]Three pigs/pen were topped on d 93 to provide 8.0 ft²/pig, topped to a common inventory of 20 pigs/pen on d 122 to provide 8.8 ft²/pig, and a common pen inventory of 17 pigs/pen on d 147 to provide 10.4 ft²/pig.

[3]Pens were topped to a common inventory of 20 pigs/pen on d 108 to provide 8.8 ft²/pig and a common inventory of 17 pigs/pen on d 147 to provide 10.4 ft²/pig.

Table 2. Diet composition, phases 1 through 6[1]

Ingredient, %	Dietary phase					
	1	2	3	4	5	6
Corn	39.39	47.08	55.49	60.74	60.52	82.76
Soybean meal, 46.5% crude protein	17.40	9.80	6.58	6.52	6.92	14.62
Corn DDGS[2]	40.00	40.00	35.00	30.00	30.00	---
Monocalcium phosphate, 21% P	0.20	0.15	0.10	0.10	0.09	0.50
Limestone	1.30	1.25	1.20	1.20	1.15	0.78
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Copper sulfate	0.03	0.03	0.03	---	---	---
L-Lysine-HCl	0.58	0.63	0.55	0.45	0.40	0.30
DL-Methionine	0.02	---	---	---	0.00	0.05
L-Threonine	0.09	0.09	0.07	0.05	0.04	0.12
L-Tryptophan	0.04	0.05	0.04	0.04	0.04	0.03
Premix[3]	0.20	0.20	0.20	0.15	0.10	0.10
Phytase[4]	0.08	0.08	0.10	0.10	0.10	0.10
Sodium metabisulfite	0.15	0.15	0.15	0.15	0.15	0.15
Starter premix[5]	0.05	---	---	---	---	---
Total	100	100	100	100	100	100

continued

Table 2. Diet composition, phases 1 through 6[1]

Ingredient, %	Dietary phase					
	1	2	3	4	5	6
Calculated analysis						
Standardized ileal digestible (SID) amino acids, %						
Lysine	1.18	1.03	0.88	0.78	0.76	0.77
Isoleucine:lysine	63	59	60	64	67	61
Leucine:lysine	166	172	183	194	203	149
Methionine:lysine	31	30	32	34	36	34
Methionine and cysteine:lysine	56	56	60	64	67	61
Threonine:lysine	62.0	60.7	60.7	63.0	64.9	67.6
Tryptophan:lysine	18.3	18.3	17.8	19.3	19.7	19.7
Valine:lysine	74	72	75	80	84	70
Total lysine	1.39	1.22	1.05	0.94	0.91	0.88
SID lysine:net energy ratio, g/Mcal	4.94	4.24	3.56	3.15	3.04	3.06
Net energy, kcal/lb	1,082	1,104	1,120	1,128	1,128	1,149
Crude protein, %	22.9	20.1	17.8	16.7	16.9	14.0
Calcium, %	0.63	0.58	0.54	0.53	0.51	0.45
Phosphorus, %	0.50	0.46	0.42	0.40	0.40	0.42
Available phosphorus, %	0.27	0.25	0.21	0.19	0.19	0.16

[1]Diets were fed in six phases from 48 to 70, 70 to 120, 120 to 180, 180 to 230, 230 to 270, and 270 lb until the end of the study.

[2]DDGS = dried distillers grains with solubles. Provided 700,000 IU vitamin A from vitamin A acetate, 200,000 IU vitamin D from vitamin D_3, 3,650 IU vitamin E from dl-α-tocophorol acetate, 400 mg menadione from menadione nicotinamide bisulfite, 3.6 mg B_{12} from cyanocobalamin, 6,800 mg niacin from niacinamide, 3,000 pantothenic acid from d-calcium panthothenate, 900 mg riboflavin from crystalline riboflavin, 1.4 g Cu from copper sulfate, 72.7 mg Ca from calcium iodate, 14 mg Fe from ferrous sulfate, 1.5 g Mn from manganese sulfate, 54.5 mg Se from sodium selenite, and 14 g Zn from zinc sulfate.

[3]Ronozyme HiPhos (GT) 2700 (DSM Nutritional Products, Parsippany, NJ) provided 1,102,300 phytase units (FTU)/kg of product with a release of 0.10% available P.

[4]Provided 850,000 IU vitamin A from vitamin A acetate, 250,000 IU vitamin D from vitamin D_3, 9,090 IU vitamin E from dl-α-tocophorol acetate, 450 mg menadione from menadione nicotinamide bisulfite, 5 mg B_{12} from cyanocobalamin, 7,500 mg niacin from niacinamide, 4,000 pantothenic acid from d-calcium panthothenate, 1,200 mg riboflavin from crystalline riboflavin, 30 mg biotin, 300 mg folic acid, 200 mg pyridoxine from pyridoxine HCl, 750 mg thiamin from thiamin hydrochloride, 1.7 g Cu from copper sulfate, 100 mg Ca from calcium iodate, 16 mg Fe from ferrous sulfate, 4.0 g Mn from manganese sulfate, 45.5 mg Se from sodium selenite, and 16 g Zn from zinc sulfate.

[5]NRC. 2012. Nutrient requirements of swine. 11th ed. Natl. Acad. Press, Washington, DC.

Table 3. Effects of space allowance and marketing strategy on growth performance of pigs raised to heavy market weights[1]

Initial floor space, ft²/pig:	12.7	10.4	8.8	7.7	7.1[2]	7.7[3]		*P*-value	
Final floor space, ft²/pig:	12.7	10.4	8.8	7.7	10.4	10.4		Fixed inventory	
Initial pigs/pen:	14	17	20	23	25	23		floor space[4]	
Marketing events:	1	1	1	1	4	3	SEM	Linear	Quadratic
BW, lb									
d 0	48.9	48.7	49.0	48.8	48.0	48.3	1.26	0.994	0.926
d 93	239.7	234.2	232.7	230.9	227.6	228.2	3.29	0.008	0.610
d 108[a]	264.9	257.1	255.9	254.9	246.8	251.2	3.09	0.005	0.276
d 122	296.4	287.5	286.2	283.6	277.2	275.8	3.19	0.002	0.397
d 135	325.6	315.5	313.3	309.0	303.5	303.8	2.96	0.001	0.527
d 147	351.5	341.9	339.9	333.9	332.3	330.2	3.22	0.001	0.814
d 160	377.3	368.6	364.9	358.5	353.4	356.4	3.50	0.001	0.925
d 0 to 93									
ADG, lb	2.04	1.99	1.97	1.96	1.92	1.92	0.025	0.002	0.450
ADFI, lb	5.22	5.04	4.98	4.99	4.83	4.87	0.070	0.003	0.191
F/G	2.57	2.54	2.53	2.55	2.51	2.54	0.019	0.321	0.165
d 93 to 108									
ADG, lb	1.66	1.48	1.51	1.57	1.70	1.51	0.069	0.230	0.057
ADFI, lb	5.86	5.53	5.51	5.57	5.45	5.39	0.109	0.026	0.086
F/G[a,c]	3.59	3.78	3.65	3.58	3.25	3.62	0.139	0.878	0.139
d 108 to 122									
ADG, lb	2.25	2.09	2.08	2.04	2.13	2.10	0.052	0.005	0.342
ADFI, lb	7.92	7.18	7.20	7.04	7.14	7.17	0.129	0.001	0.054
F/G	3.52	3.45	3.47	3.46	3.35	3.433	0.0765	0.585	0.659
d 122 to 135									
ADG, lb[a,b]	2.26	2.15	1.99	1.95	2.12	2.12	0.072	0.001	0.917
ADFI, lb	7.99	7.54	7.39	7.22	7.44	7.42	0.110	0.001	0.459
F/G	3.57	3.54	3.75	3.75	3.53	3.50	0.106	0.073	0.513
d 135 to 147									
ADG, lb[a,b,c]	2.16	2.20	2.21	2.02	2.41	2.21	0.063	0.208	0.064
ADFI, lb[a,b]	8.12	7.87	7.56	7.27	7.87	7.77	0.114	0.001	0.199
F/G[a,c]	3.76	3.59	3.45	3.63	3.28	3.52	0.083	0.070	0.121
d 147 to 160									
ADG, lb	1.98	2.05	1.93	1.84	1.90	2.16	0.105	0.145	0.183
ADFI, lb[b]	8.40	8.18	7.84	7.66	8.01	8.32	0.256	0.001	0.583
F/G	4.28	4.03	4.09	4.18	4.33	3.86	0.145	0.580	0.212

Table 3. Effects of space allowance and marketing strategy on growth performance of pigs raised to heavy market weights[1]

								P-value	
Initial floor space, ft²/pig:	12.7	10.4	8.8	7.7	7.1[2]	7.7[3]		Fixed inventory	
Final floor space, ft²/pig:	12.7	10.4	8.8	7.7	10.4	10.4		floor space[4]	
Initial pigs/pen:	14	17	20	23	25	23			
Marketing events:	1	1	1	1	4	3	SEM	Linear	Quadratic
d 0 to 160									
ADG, lb	2.04	1.98	1.95	1.92	1.96	1.95	0.017	0.001	0.713
ADFI, lb	6.20	5.91	5.82	5.77	5.64	5.72	0.069	0.001	0.169
F/G[a,b,c]	3.04	2.99	2.98	3.00	2.87	2.94	0.021	0.091	0.040
Adjusted F/G[5]	2.59	2.58	2.60	2.65	2.60	2.62	0.022	0.053	0.055
Performance during topping events									
d 93 to 160									
ADG, lb[a,b]	2.05	1.97	1.93	1.87	2.03	1.99	0.028	0.001	0.941
ADFI, lb	7.60	7.18	7.03	6.90	7.07	7.06	0.084	0.001	0.314
F/G[a,b]	3.70	3.65	3.65	3.69	3.48	3.56	0.042	0.665	0.143
Removals, %	2.6	7.2	7.3	5.8	7.8	7.4	2.4	0.182	0.131
Total weight gain, lb/pen	4,458	4,979	5,778	6,581	6,582	6,328	210.4	0.001	0.042
Total weight gain, lb/pig[a,b,c]	327[a]	316[b]	312[b,c]	306[c]	288[e]	298[d]	3.0	0.001	0.810

BW = body weight. ADG = average daily gain. ADFI = average daily gain. F/G = feed efficiency.

[a]Pigs stocked at 7.7 ft²/pig with one marketing event vs. pigs initially stocked at 7.1 ft²/pig with 4 marketing events are significantly different ($P < 0.05$).

[b]Pigs stocked at 7.7 ft²/pig with one marketing event vs. pigs initially stocked at 7.7 ft²/pig with 3 marketing events are significantly different ($P < 0.05$).

[c]Pigs stocked at 7.1 ft²/pig with 4 marketing events vs. pigs initially stocked at 7.7 ft²/pig with 3 marketing events are significantly different ($P < 0.05$).

[1]A total of 976 finishing pigs (initially 58 ± 3.4 lb BW) were used in a 160-d experiment to evaluate the effects of pig space allowance and marketing strategy on finishing pigs raised to heavier weights.

[2]Three pigs/pen were topped on d 93 to provide 8.0 ft²/pig, topped to a common inventory of 20 pigs/pen on d 122 to provide 8.8 ft²/pig, and a common pen inventory of 17 pigs/pen on d 147 to provide 10.4 ft²/pig.

[3]Pens were topped to a common inventory of 20 pigs/pen on d 108 to provide 8.8 ft²/pig and a common inventory of 17 pigs/pen on d 147 to provide 10.4 ft²/pig.

[4]Treatments 1 through 4 that did not employ topping were evaluated using linear and quadratic contrasts.

[5]Calculated as adjusted F/G = [285 − final BW] × 0.0048 + actual overall F/G.

Table 4. Determination of *k*-values for different space allocations and pig weights[1,2]

Item	Marketing events:	12.7	10.4	8.8	7.7	7.1[3]	7.7[4]
Initial floor space, ft²/pig:		12.7	10.4	8.8	7.7	7.1[3]	7.7[4]
Final floor space, ft²/pig:		12.7	10.4	8.8	7.7	10.4	10.4
Initial pigs/pen:		14	17	20	23	25	23
Item	Marketing events:	1	1	1	1	4	3
d 0							
BW, lb		48.9	48.7	49.0	48.8	48	48.3
ft²/pig		12.6	10.4	8.8	7.7	7.1	7.7
k-value[5]		0.1471	0.1215	0.1028	0.0896	0.0834	0.0903
d 55							
BW, lb		152.6	149.8	148.5	149.4	146.2	145.7
ft²/pig		12.6	10.4	8.8	7.7	7.1	7.7
k-value		0.0702	0.0580	0.0500	0.0433	0.0403	0.0440
d 93							
BW, lb		239.7	234.2	232.7	230.9	227.6	228.2
ft²/pig		12.6	10.4	8.8	7.7	7.1	7.7
k-value		0.0519	0.0430	0.0370	**0.0323**	**0.0300**	**0.0326**
ft²/pig after topping						8.0	
k-value after topping						0.0364	
d 108							
BW, lb		264.9	257.1	255.9	254.9	246.8	251.2
ft²/pig		12.7	10.4	8.9	7.7	8.0	7.7
k-value		0.0485	0.0404	0.0347	**0.0303**	0.0345	**0.0306**
ft²/pig after topping							8.8
k-value after topping							**0.0344**
d 122							
BW, lb		296.4	287.5	286.2	283.6	277.2	275.8
ft²/pig		12.7	10.4	8.9	7.7	8.0	8.8
k-value		0.0450	0.0375	**0.0322**	**0.0282**	0.0319	**0.0323**
ft²/pig after topping						8.8	
k-value after topping						**0.0322**	
d 135							
BW, lb		325.6	315.5	313.3	309.0	303.5	303.8
ft²/pig		12.7	10.4	8.9	7.7	8.8	8.8
k-value		0.0422	0.0352	**0.0303**	**0.0266**	**0.0303**	**0.0303**
d 147							
BW, lb		351.5	341.9	339.9	333.9	332.3	330.2
ft²/pig		12.7	10.4	8.9	7.7	8.8	8.8
k-value		0.0401	**0.0334**	**0.0287**	**0.0253**	**0.0285**	**0.0286**
ft²/pig after topping						10.4	10.4
k-value after topping						**0.0335**	0.0337

continued

Table 4. Determination of *k*-values for different space allocations and pig weights[1,2]

Item	Marketing events:	12.7	10.4	8.8	7.7	7.1[3]	7.7[4]
Initial floor space, ft²/pig:		12.7	10.4	8.8	7.7	7.1[3]	7.7[4]
Final floor space, ft²/pig:		12.7	10.4	8.8	7.7	10.4	10.4
Initial pigs/pen:		14	17	20	23	25	23
Item	Marketing events:	1	1	1	1	4	3
d 160							
BW, lb		377.3	368.6	364.9	358.5	353.4	356.4
ft²/pig		12.7	10.4	8.9	7.7	10.4	10.4
k-value		0.0383	**0.0317**	**0.0274**	**0.0241**	**0.0322**	**0.0320**

[1]A total of 976 finishing pigs (initially 48 ± 3.4 lb body weight (BW)) were used in a 160-d experiment to evaluate the effects of pig space allowance and marketing strategy on growth performance of finishing pigs raised to heavy market weights.

[2]Values in bold represent *k*-values less than the critical *k*-value of 0.0336.

[3]Three of the heaviest pigs/pen were removed on d 93. The heaviest pigs were also removed to achieve a common pen inventory of 20 pigs/pen on d 122 and 17 pigs/pen on d 147.

[4]The heaviest pigs were removed to reach a common pen inventory of 20 pigs/pen on d 108 and 17 pigs/pen on d 147.

[5]Defined as A, m² = $k \times$(BW$^{0.67}$, kg) as described by Gonyou et al. (2006).