

Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 10 *Swine Day (1968-2014)*

Article 1061

2014

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Recommended Citation

Flohr, Joshua R.; DeRouchey, Joel M.; Tokach, Michael D.; Woodworth, Jason C.; Dritz, Steven S.; Goodband, Robert D.; Houser, Terry A.; Felder, C A.; and Prusa, K J. (2014) "Effects of high levels of dietary niacin from nicotinic acid on growth and meat quality of finishing pigs raised during summer," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 10. <https://doi.org/10.4148/2378-5977.6901>

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Effects of High Levels of Dietary Niacin from Nicotinic Acid on Growth and Meat Quality of Finishing Pigs Raised During Summer¹

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Summary

A total of 1,232 pigs (PIC 337 × 1050; initially 59.4 lb) were used in a 98-d study to evaluate the influence of increasing dietary niacin supplementation on growth, body temperatures, and meat quality of pigs raised in a commercial facility during the summer. There were 28 pigs per pen and 11 pens per treatment. Basal diets contained corn, soybean meal, and dried distillers grains with solubles (DDGS). The four dietary treatments were formed by adding increasing levels of nicotinic acid as the source of niacin (Lonza, Allendale, NJ) at 14, 172, 331, and 490 mg/lb of complete feed. On d 57, 58, and 59, rectal temperatures and skin temperatures on the top of the shoulder and rump were collected from 2 pigs per pen (1 barrow and 1 gilt). On d 98, 2 pigs per pen (1 barrow and 1 gilt) were visually selected as the heaviest pigs in the pen and were harvested for carcass and meat quality data. Carcass traits, pH decline, and subjective loin color and marbling scores were measured at a commercial abattoir. Afterward, a 15.7-in. segment of the loin was used for meat quality analysis, including measurements of ultimate pH and purge loss. Boneless chops (1 in. thick) were cut from the loin segment and were used to determine 24-h drip loss, subjective color and marbling, objective lean color values (L^* , lightness; a^* , redness; and b^* , yellowness), and muscle niacin concentrations.

Average daily temperatures within the barn ranged from 63.8 to 85.5°F throughout the length of the study, with daily low temperatures from 59.9 to 81.0°F and daily high temperatures from 66.1 to 93.3°F. Overall, temperature was cooler than expected for the facility compared with normal seasonal increases associated with the summer months.

Time × day interactions ($P < 0.01$) were observed for rectal, shoulder, and rump temperatures; however, body temperature was not consistently influenced by dietary niacin concentrations during the collection period.

Overall (d 0 to 98), increasing dietary niacin did not influence ADG or F/G, but it tended (linear; $P = 0.07$) to increase ADFI. Increasing niacin supplementation did not influence carcass traits; however, for meat quality, it did increase (linear; $P < 0.01$) pH decline at 45 min and 21 h postmortem. Increases (linear; $P < 0.05$) in a^* and b^* were observed for chops from pigs fed increasing niacin, but subjective chop color scores were not affected by increasing niacin supplementation. In summary, dietary niacin above the animal's requirement estimate did not consistently influence rectal or skin tempera-

¹ Appreciation is expressed to the National Pork Board for funding this trial as project number 13-093.

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tures and had negligible influences on growth performance, carcass traits, and meat quality parameters.

Key words: heat stress, niacin, nicotinic acid, finishing pig

Introduction

Niacin is a component of the coenzymes nicotinamide-adenine dinucleotide (NAD) and nicotinamide-adenine dinucleotide phosphate (NADP). These coenzymes are required for the normal metabolism of carbohydrates, proteins, and fats due to their redoxing and oxidizing abilities. Two main forms of niacin are available for use as supplements in swine diets; these are nicotinamide and nicotinic acid. Both forms act as exogenous precursors for the metabolically active forms of the vitamin (NAD and NADP); however, nicotinic acid is also known for other functions in the body. In human medicine, pharmacological doses of nicotinic acid are commonly used to help reduce circulating lipid concentrations by reducing LDL and vLDL cholesterol and increasing HDL cholesterol. One of the largest side effects associated with pharmacological dosing of nicotinic acid is an increase in skin vasodilation known as flushing. Although it is seen as a negative side effect in humans, this increase in vasodilation could act as a mediator of seasonal heat stress in swine by increasing blood circulation to the periphery of the body, thus allowing for increased heat abatement by the animal.

Heat stress is a major contributor to seasonal losses experienced in pig production. Economic losses were estimated to total approximately \$200 million dollars (St. Pierre et al., 2003³) in the grower and finishing pig sector in the form of decreased performance, lowered market weights, increased days on feed, and mortality of finishing pigs. Previous research by Zimbelman et al. (2010⁴) in dairy cows concluded that niacin was successful at reducing heat stress in milking cows during periods of high temperatures in the form of reduced rectal and vaginal temperatures and increased evaporative heat loss. No research has examined the influence of pharmacological doses of nicotinic acid on growing and finishing pig performance during seasonal heat stress.

Other interests associated with niacin supplementation in finishing pigs are potential influences on carcass meat quality. Real et al. (2002⁵) examined the influence of nicotinic acid supplementation on meat quality of commercially reared pigs and concluded that increasing nicotinic acid supplementation from 0 to 249 mg/lb of complete feed increased 24-h pH and improved meat color. The objectives of this study were to examine the influence of pharmacological doses of nicotinic acid on growth performance, body temperature, and meat quality of pigs raised in a commercial setting during summer months.

³ St. Pierre, N.R., B. Cobanov, and G. Schnitkey. 2003. Economic losses from heat stress by US livestock industries. *J. Dairy Sci.* 86(E-suppl.):E52–E77.

⁴ Zimbelman, R.B., L.H. Baumgard, and R.J. Collier. 2010. Effects of encapsulated niacin on evaporative heat loss and body temperature in moderately heat-stressed lactating Holstein cows. *J. Dairy Sci.* 93:2387–2394.

⁵ Real, D.E., J.L. Nelssen, J.A. Unruh, M.D. Tokach, R.D. Goodband, S.S. Dritz, J.M. DeRouchey, and E. Alonso. 2002. Effects of increasing dietary niacin on growth performance and meat quality in finishing pigs reared in two different environments. *J. Anim. Sci.* 80:3203–3210.

Procedures

Experimental procedures and animal care were approved by the Kansas State University Institutional Animal Care and Use Committee. This experiment was conducted in a commercial research-finishing barn in southwestern Minnesota. The barn was naturally ventilated and double-curtain-sided with completely slatted flooring and a deep pit for manure storage. Pens were equipped with a cup waterer and 4-hole stainless steel dry feeder (56 in. wide) manufactured by Thorp Equipment, Inc. (Thorp, WI) to provide ad libitum access to feed and water. Daily feed additions to each pen were accomplished through a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN) capable of providing and measuring feed deliveries on an individual pen basis.

Three temperature loggers (LogTag Recorders, New Zealand) were placed in the barn to collect daily ambient temperature and relative humidity. Readings were recorded hourly throughout the day on each logger, and average hourly temperature and humidity were determined. Hourly data were used to calculate daily high, low, and average values (Figure 1).

A total of 1,232 pigs (PIC 337 × 1050; initially 59.4 lb) were used in a 98-d study to evaluate the influence of pharmacological doses of nicotinic acid on growth, body temperatures, and meat quality. At initiation of the study, pens were allotted to treatments in a randomized complete block design with location within barn as the blocking factor. There were 4 dietary treatments with 11 pens per treatment.

The 4 dietary treatments were increasing levels of nicotinic acid (Lonza, Allendale, NJ) at 14, 172, 331 and 490 mg/lb (Table 1). Diets were formulated such that the first diet met the pig's estimated requirement (14 mg/lb) for niacin, with further additions exceeding the niacin requirement. The basal diet was corn-soybean meal-based and contained 10% dried distillers grains with solubles (DDGS). Diets were formulated to meet or exceed the nutrient requirements of the pigs as defined by NRC (2012⁶). These diets were fed in 4 phases from approximately 60 to 90, 90 to 150, 150 to 215, and 215 to 245 lb BW. Experimental diets were subsampled and samples were sent to a commercial laboratory (Ward Laboratories Inc., Kearney, NE) for analysis (DM, CP, fat, ash, Ca, and P), and subsamples were also shipped to another commercial laboratory (AIB International, Manhattan, KS) for dietary niacin concentrations.

Pigs and feeders were weighed approximately every 14 d to determine ADG, ADFI, and F/G. On d 57, 58, and 59 (August 8, 9, and 10, respectively), a randomly selected barrow and gilt within each pen were used to determine pig rectal and body temperatures throughout the day. On each collection day, rectal temperatures were collected using electronic thermometers (SureTemp Plus 692; Welch Allyn, San Diego, CA), and skin temperatures were taken on the top of the shoulder and rump using an infrared dual laser thermometer (Model 42512; Extech Instruments Corporation, Waltham, MA). Temperatures were collected from the same pigs within each pen at 6:00 and 9:00 a.m. and 12:00, 3:00, and 6:00 p.m. during the three consecutive collection days.

On d 98, the heaviest barrow and gilt (determined visually) from each pen were marketed following normal farm procedures. Pigs were tattooed by gender and pen and

⁶ NRC. 2012. Nutrient Requirements of Swine. 11th ed. Natl. Acad. Press, Washington, DC.

transported to JBS Swift and Company (Worthington, MN) for processing and carcass data collection. Hot carcass weights were measured immediately after evisceration, and each carcass was evaluated for percentage yield, backfat, and loin depth. Percentage yield was calculated by dividing HCW by live weight obtained at the farm before transport to the abattoir. Fat depth and loin depth were measured with an optical probe (SFK; Herlev, Denmark) inserted between the 3rd and 4th ribs located anterior to the last rib at a distance approximately 2.8 in. from the dorsal midline. Fat-free lean index (FFLI) was calculated using NPPC (20007) guidelines for carcasses measured with the optical probe such that $FFLI = ((15.31 + (0.51 \times HCW, lb) - (31.277 \times \text{last-rib fat thickness, in.}) + (3.813 \times \text{loin muscle depth, in.}))/HCW, lb$.

All meat quality was performed using the left side of the carcass. All pH measurements were collected using a pH meter (Model 9025, Hanna Instruments, Smithfield, RI) with a glass-tip probe. The pH measurements were taken at three time points to evaluate the pH decline post-slaughter at 45 min, 3 h, and 21 h. At the 45-min and 3-h time points, the probe was inserted into the longissimus dorsi (LD) between the 10th and 11th rib. Approximately 20.5 h postmortem, carcasses were fabricated for sample collection and additional analysis. A 15.7-in. section of the LD was removed from the posterior end of the loin, individually labeled, and allowed to bloom for 30 min. After blooming, subjective color and marbling scores were determined by a trained evaluator using the 1 to 6 scoring system for color and the 1 to 5 scoring system for marbling (NPPC, 2001). In addition, the 21-h pH was recorded by again placing the probe into the LD at a central position across the sirloin face. The LD was subsequently vacuum-packaged and transported on ice to the Kansas State University Meats Laboratory for subsequent analysis. Samples were stored at 39.2°F and aged for 10 d post-slaughter.

After aging, purge loss was measured by initially weighing the packaged LD, then removing the packaging and pat-drying both the package and the LD sample. After weighing the dried package and LD sample, purge loss was calculated as a percentage of the original LD weight. Ultimate pH was then recorded by placing the probe into the LD at a central position across the sirloin face. Afterward, 3 1-in.-thick boneless chops were fabricated from the anterior end of the loin. The first chop was trimmed to approximately 100 g of lean to estimate 24-h drip loss; these samples were bagged individually and stored at 39.2°F for 24 h, after which samples were pat-dried and reweighed to calculate 24-h drip loss as a percentage of original sample weight. The second LD chop was placed on a 1 S polystyrene tray (Dyne-A-Pak Inc., LAVAL, QC, Canada) and was overwrapped with a polyvinylchloride film (23,250 mL of O₂/m²/24 h oxygen permeability/flow rate). The packages were placed in an open-top retail display case (unit model DMF8, Tyler Refrigeration Corp., Niles, MI) at 35.6°F ± 3.6°F and were allowed to bloom for 45 min. After blooming, subjective color and marbling score were determined by 3 trained evaluators using the previously discussed scoring systems (NPPC, 2000⁷). Objective color measurements of lean color were then determined using a HunterLab Miniscan XE Plus spectrophotometer (Model 45/0 LAV, 2.54-cm-diameter aperture, 10° standard observer, Illuminant D65, Hunter Associates Laboratory, Inc., Reston, VA) to measure CIE L* (lightness), a* (redness), and b* (yellowness). The spectrophotometer was calibrated against a standard white tile

⁷ NPPC. 2000. Procedures for Estimating Pork Carcass Composition. Natl. Pork Prod. Council, Des Moines, IA.

(Hunter Associates Laboratory), and 2 locations of the lean surface of each sample were measured and averaged to determine the CIE L^* , a^* , and b^* values. The third chop was frozen at -4°F until subsampling; these subsamples were individually flash-frozen using liquid nitrogen and then pulverized. Afterward, 0.5 g of pulverized sample was weighed and niacin was extracted in solution using an acid hydrolysis technique discussed by the European Committee for Standardization (2009⁸). These extracted samples were analyzed in duplicate using high-performance liquid chromatography (HPLC) analysis. Final loin niacin concentrations are expressed as mg/lb of tissue.

Data were analyzed as a randomized complete block design using PROC MIXED in SAS (SAS Institute, Inc., Cary, NC). Linear and quadratic polynomial contrasts were used to determine the effects of increasing nicotinic acid. Pen served as the experimental unit for growth performance. Carcass data were analyzed as a split plot design with pig as the experimental unit to evaluate the effects of gender. Temperature data were also analyzed as a split plot design to evaluate the effects of gender using repeated measures, with time $\times$ day interactions as the repeated variable and pig as the subject. In addition, a Toeplitz covariance model was used for the temperature analysis. This covariance structure assumes that pairs of within-subject errors separated by a common lag share the same correlation, and it provided the best fit of the temperature data (as measured by smaller AIC, AICC, and BIC values).

Results

Daily average temperatures within the barn ranged from 63.8 to 85.5°F (Figure 1) throughout the length of the study; meanwhile, daily low temperatures were 59.9 to 81.0°F, and daily high temperatures were 66.1 to 93.3°F. Daily average humidity ranged from 44.9 to 85.5% relative humidity, with low daily humidity measurements from 26.3 to 76.0% and daily high humidity from 58.2 to 91.4%. In general, temperature was cooler than expected for the facility compared with previous seasonal increases associated with summer months, and humidity was variable throughout the length of the study. As a result, the degree of seasonal heat stress observed during this study was less than anticipated.

Experiment diets were analyzed for niacin content at a commercial laboratory (AIB International, Manhattan, KS). Diets formulated to contain 14, 172, 331, and 490 mg/lb were determined to contain niacin concentrations of 18, 117, 256, and 564 mg/lb (Table 2), respectively.

Average daily gain and F/G from d 0 to 98 were not influenced by increasing dietary niacin ($P > 0.17$; Table 3), but ADFI tended to increase with increasing dietary niacin (linear; $P = 0.07$). The current study suggests that additional supplementation of niacin above the animal's requirement does not influence ADG or F/G. However, the study was designed to test the influence of increasing niacin during heat stress, and unfortunately heat stress was minimal during the study. Nevertheless, our data are in agreement with that of Real et al. (2001), who concluded that 6 to 24 mg/lb of added niacin are needed to maximize gain and feed efficiency.

⁸ European Committee for Standardization. 2009. Foodstuffs – Determination of niacin by HPLC. Tech. Bull. No. 15652. British Standards Institution, United Kingdom.

No dietary niacin $\times$ gender interactions were observed for carcass trait data. Carcass traits were not influenced ($P > 0.05$; Table 4) by dietary niacin; however, barrows had heavier final live weights, HCW, and increased yield percentages ($P < 0.03$) than gilts. Gilts had lower body fat, increased loin depth, and higher FFLI ($P = 0.01$) than barrows.

Increased dietary niacin reduced 45-min pH (linear; $P = 0.01$). A dietary niacin $\times$ gender interaction ($P = 0.01$; Table 5) was observed for the 3-h pH measurement because barrows fed 14 and 331 mg/lb niacin had lower pH values than gilts fed the same diets, whereas barrows fed 172 and 490 mg/lb had higher pH values than gilts fed the same diets. This was the only interaction observed for meat quality data. Increasing dietary niacin reduced 21-h pH (linear; $P = 0.01$). Ultimate pH was not altered ($P > 0.11$) by dietary niacin, but barrows ($P = 0.02$) had higher ultimate pH than gilts. Subjective color and marbling scores of loins and boneless chops were not influenced ($P > 0.22$) by dietary niacin. Barrows had higher ($P = 0.04$) boneless chop color and marbling scores and tended ($P = 0.08$) to have higher loin marbling scores than gilts. Purge loss and 24-h drip loss did not differ ($P > 0.18$) among dietary niacin treatments or genders. In terms of objective lean color scores, increasing dietary niacin increased (linear; $P < 0.05$) a^* and b^* values. Boneless chop niacin concentrations were not influenced ($P > 0.56$) by dietary niacin treatments or gender.

Overall, the current study suggests that supplementation of niacin from 14 to 490 mg/lb does not drastically affect pork quality. This contrasts with previous meat quality research by Real et al. (2001), who observed improved color and pH with increasing niacin supplementation up to 227 mg/lb. One reason for the difference in results may be that carcasses in the current study underwent chilling in a blast chiller, which may have mitigated some effects on meat quality that were previously observed during a longer chilling period. In a recent study, Khan et al. (2013⁹) concluded that feeding 340 mg/lb nicotinic acid to intact boars resulted in an increase in muscle fiber switching from glycolytic type II fibers to oxidative type I fibers. The authors hypothesized that this may lead to an increase in dark, firm, and dry pork. The current study would be in difference with that conclusion given that subjective color was not different among niacin treatments and that pH decline was actually increased by niacin supplementation.

A time $\times$ day interaction ($P < 0.01$; Figure 2) was observed for rectal temperatures, but no dietary niacin $\times$ gender interactions were found within specific time $\times$ day collection points. At 6:00 a.m. on d 1, increasing dietary niacin increased (linear; $P = 0.02$) rectal temperature; however, at 12:00 on d 1, increasing niacin decreased (quadratic; $P = 0.03$) rectal temperatures, with pigs fed 172 mg/lb having the lowest temperatures. In addition, barrows had higher rectal temperatures at 3:00 and 6:00 p.m. on d 1 and at 3:00 p.m. on d 3. Overall, the inconsistent differences in rectal temperatures across dietary treatments suggest that dietary niacin supplementation did not biologically affect core body temperatures during the collection period. This conclusion disagrees with previous research conducted in dairy cows that concluded supplementing high doses of niacin reduced rectal and vaginal temperatures and increased evaporative heat loss.

⁹ Khan, M., R. Ringseis, F. Mooren, K. Kruger, E. Most, and K. Eder. 2013. Niacin supplementation increases the number of oxidative type I fibers in skeletal muscle of growing pigs. BMC Veterinary Research 9:177.

For shoulder and rump skin temperatures, time $\times$ day interactions (Figures 3 and 4; $P < 0.01$) were also observed. Shoulder skin temperatures were increased (linear, $P = 0.05$) at 6:00 a.m. on d 1 with increased dietary niacin, and gilts had higher ($P = 0.04$) shoulder skin temperatures than barrows. Shoulder and rump temperatures decreased (quadratic; $P < 0.04$) with increased dietary niacin at 9:00 a.m. on d 1, with pigs fed 172 mg/lb having the lowest skin temperatures. On d 2 at 6:00 a.m., a gender $\times$ dietary niacin interaction ($P = 0.03$) was observed for shoulder skin temperature because barrows fed 331 mg/lb niacin had higher temperatures than gilts fed the same diet, but barrows fed 14, 172, or 490 mg/lb niacin had lower temperatures than gilts fed the same diets. Also on d 2 at 9:00 a.m., decreased (linear; $P = 0.05$) shoulder skin and rump temperatures were observed for pigs fed increasing dietary niacin. On d 3 at 3:00 p.m., increasing ($P = 0.05$) skin temperatures were observed for pigs fed increasing dietary niacin, with pigs fed 331 mg/lb having the highest temperatures. Similar to rectal temperature data, dietary niacin supplementation appears not to have altered skin temperatures consistently over the collection period.

In the current study, seasonal heat stress within a commercial operation unfortunately was not as great as desired. Regardless, this study suggests that increasing dietary niacin to finishing pigs above their requirement does not consistently influence growth performance, carcass traits, meat quality, or pig body temperatures.

Table 1. Diet composition (as-fed basis)¹

Item	Phase 1	Phase 2	Phase 3	Phase 4
Corn ²	55.19	60.14	64.56	66.76
Soybean meal (46.5% CP)	22.47	17.68	13.40	11.36
Corn DDGS ³	20.00	20.00	20.00	20.00
Limestone	1.10	1.20	1.15	1.05
Salt	0.35	0.35	0.35	0.35
Dicalcium phosphate	0.15	---	---	---
DL-methionine	0.01	---	---	---
L-threonine	0.05	0.02	---	---
Lysine sulfate	0.51	0.44	0.39	0.33
Phytase ⁴	0.02	0.02	0.02	0.02
Vitamin premix ⁵	0.08	0.08	0.08	0.08
Trace mineral premix ⁶	0.07	0.07	0.05	0.05
Total	100.0	100.0	100.0	100.0

continued

Table 1. Diet composition (as-fed basis)¹

Item	Phase 1	Phase 2	Phase 3	Phase 4
Calculated analysis				
Standardized ileal digestible (SID) amino acids, %				
Lysine	1.06	0.91	0.78	0.70
Isoleucine:lysine	68	70	73	76
Methionine:lysine	30	32	35	37
Met & cys:lysine	56	60	65	70
Threonine:lysine	62	62	63	66
Tryptophan:lysine	18.0	18.0	18.0	18.5
Valine:lysine	77	82	86	91
Total lysine, %	1.24	1.08	0.94	0.85
CP, %	21.2	19.2	17.5	16.6
ME, kcal/lb	1,505	1,507	1,510	1,512
SID lysine:ME, g/Mcal	3.20	2.74	2.34	2.10
Ca, %	0.53	0.52	0.49	0.44
P, %	0.45	0.40	0.38	0.37
Available P, %	0.30	0.27	0.26	0.26
Analyzed dietary concentrations ⁷				
DM, %	90.80	90.14	90.30	89.75
CP, %	21.9	19.7	17.6	18.3
Fat, %	4.18	4.03	4.10	4.48
Ash, %	4.63	4.53	3.82	3.93
Ca, %	0.68	0.74	0.55	0.50
P, %	0.43	0.39	0.35	0.39

¹ Diets were fed in meal form during the experiment. Diets were fed in 4 phases from approximately 60 to 90, 90 to 150, 150 to 215, and 215 to 245 lb BW.

² The 4 dietary treatments were obtained by replacing corn in each diet with nicotinic acid (Lonza, Allendale, NJ) to achieve total niacin concentrations of 14, 172, 331, and 490 mg/lb of complete feed.

³ Dried distillers grains with solubles.

⁴ Optiphos 2000 (Enzyvia, Sheridan, IN) provided 363.2 phytase units (FTU)/lb, with a release of 0.12% available P.

⁵ Provided per pound of premix: 3,200,000 IU vitamin A; 500,000 IU vitamin D₃; 16,000 IU vitamin E; 1,600 mg vitamin K; 2,800 mg riboflavin; 10,000 mg pantothenic acid; 18,000 IU niacin; 12 mg vitamin B₁₂.

⁶ Provided per pound of premix: 50 g Zn from zinc sulfate; 50 mg Fe from iron sulfate; 15 g Mn from manganese oxide; 7.5 g Cu from copper sulfate; 150 mg I from calcium iodate; and 136 mg Se from sodium selenite.

⁷ Analysis performed by Ward Laboratories Inc. (Kearney, NE); means represent the average of 4 samples within each dietary phase.

Table 2. Analyzed dietary niacin concentrations¹

		Dietary niacin, mg/lb			
Formulated	14	172	331	490	
Analyzed	18	117	256	564	

¹ Analysis performed by AIB International (Manhattan, KS). Means represent the average of duplicate samples that were obtained by pooling samples across dietary phases within experimental treatments.

Table 3. Effects of increasing dietary niacin on finishing pig growth performance^{1,2}

Item	Dietary niacin, mg/lb ³				SEM	Probability, <i>P</i> <	
	14	172	331	490		Linear	Quadratic
d 0 to 98							
ADG, lb	1.81	1.81	1.82	1.81	0.01	0.40	0.50
ADFI, lb	4.47	4.59	4.63	4.56	0.04	0.07	0.71
F/G	2.48	2.54	2.54	2.51	0.02	0.17	0.89
BW, lb							
d 0	59.4	59.4	59.4	59.4	1.1	1.00	0.98
d 98	239.3	238.1	239.3	239.3	1.5	0.85	0.60

¹ A total of 1,232 pigs (PIC 337 × 1050; initially 59.4 lb) were used in a 98-d study to determine the influence of increasing dietary niacin concentrations on growth performance. There were 11 pens per treatment and 28 pigs per pen.

² The study was ended on d 98 prior due to a facility electronic malfunction.

³ Nicotinic acid was used as the source of added niacin to achieve dietary treatment concentrations.

Table 4. Main effects of gender and dietary niacin concentration on carcass traits and meat quality measurements¹

Item	Gender		SEM	Dietary niacin, mg/lb				SEM	Probability, <i>P</i>		
	Barrow	Gilt		14	172	331	490		Gender	Niacin	
										Linear	Quadratic
Carcass traits											
Live wt, lb	274.7	268.8	2.0	271.1	267.3	273.3	275.3	2.7	0.02	0.11	0.23
HCW, lb	201.1	194.1	1.4	196.5	195.5	199.5	198.9	2.0	0.01	0.19	0.26
Yield, %	73.3	72.4	0.4	72.7	73.1	73.1	72.3	0.5	0.03	0.48	0.81
Loin depth, in. ²	2.60	2.73	0.03	2.63	2.69	2.67	2.68	0.05	0.01	0.59	0.56
Backfat, in. ²	0.68	0.56	0.02	0.62	0.62	0.62	0.60	0.03	0.01	0.68	0.90
FFLI, % ^{2,3}	53.1	55.3	0.4	54.1	54.1	54.1	54.4	0.05	0.01	0.68	0.90
pH											
45 min	6.47	6.49	0.05	6.66	6.51	6.41	6.35	0.14	0.86	0.01	0.95
3 h	6.28	6.40	0.03	6.39	6.30	6.37	6.28	0.04	0.01	0.19	0.09
21 h	5.95	5.92	0.01	5.99	5.93	5.92	5.91	0.02	0.11	0.01	0.51
Ultimate	5.86	5.80	0.02	5.87	5.81	5.84	5.80	0.03	0.02	0.11	0.17
Meat quality											
Loin color ⁴	3.47	3.33	0.08	3.43	3.34	3.44	3.39	0.11	0.15	0.92	0.47
Loin marbling ⁴	1.50	1.34	0.07	1.43	1.27	1.42	1.55	0.10	0.08	0.22	0.43
Chop color ⁴	3.04	2.83	0.07	3.05	2.83	2.93	2.92	0.11	0.04	0.54	0.38
Chop marbling ⁴	1.70	1.55	0.05	1.63	1.61	1.57	1.69	0.08	0.04	0.65	0.56
Purge loss, %	1.39	1.60	0.14	1.45	1.40	1.51	1.62	0.21	0.27	0.47	0.85
24-h drip loss, %	2.88	3.04	0.26	2.97	2.83	3.42	2.62	0.38	0.63	0.76	0.18
L*	53.41	54.35	0.55	53.12	54.67	53.56	54.16	0.82	0.21	0.54	0.21
a*	18.61	18.61	0.26	18.20	18.30	18.89	19.05	0.39	0.99	0.05	0.58
b*	16.54	16.69	0.27	16.05	16.45	16.88	17.09	0.40	0.69	0.04	0.89
Loin niacin, mg/lb	52.23	52.39	2.53	53.45	49.54	50.20	56.04	3.57	0.96	0.56	0.97

¹ A total of 88 pigs (2 per pen; 1 barrow and 1 gilt) were used to determine the effects of gender and dietary niacin concentration on carcass traits and meat quality.

² Adjusted with HCW as a covariate.

³ Fat-free lean index (FFLI) was calculated using NPPC (2000) guidelines for carcasses measured with an optical probe such that $FFLI = (15.31 + (0.051 \times HCW, lb) - (31.277 \times \text{last rib fat thickness, in.}) + (3.813 \times \text{loin muscle depth, in.})) / HCW, lb$.

⁴ Subjective color scores were conducted using a scale of 1 to 5, and marbling scores were conducted using a numeric scale of 1 to 5 both are previously described by NPPC (2000).

Table 5. Interactive effects of gender and dietary niacin on carcass pH¹

Item	Dietary niacin treatment								SEM	Probability, $P <$ Interaction
	14		172		331		490			
	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt		
pH										
45 min	6.48	6.83	6.59	6.42	6.51	6.32	6.31	6.39	0.12	0.08
3 h	6.28	6.50	6.32	6.28	6.21	6.54	6.30	6.27	0.06	0.01
21 h	5.98	6.00	5.96	5.89	5.91	5.93	5.96	5.87	0.03	0.09
Ultimate	5.90	5.84	5.84	5.77	5.91	5.77	5.80	5.79	0.05	0.60

¹ A total of 88 pigs (2 pigs per pen; 1 barrow and 1 gilt) were used to determine the effects of gender and dietary niacin on carcass pH.

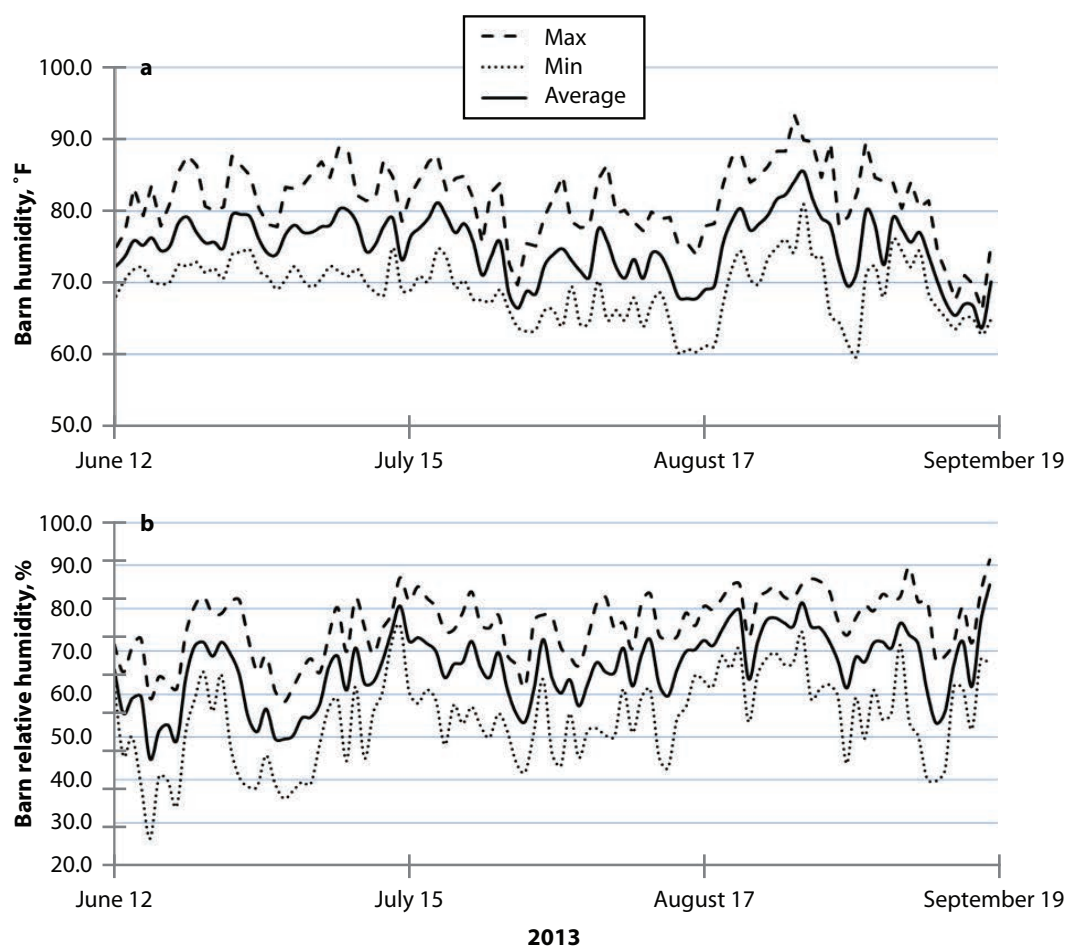


Figure 1. Temperature (°F) and relative humidity (%) of research barn from d 0 to 98 of study (June 12 through September 18, 2013).

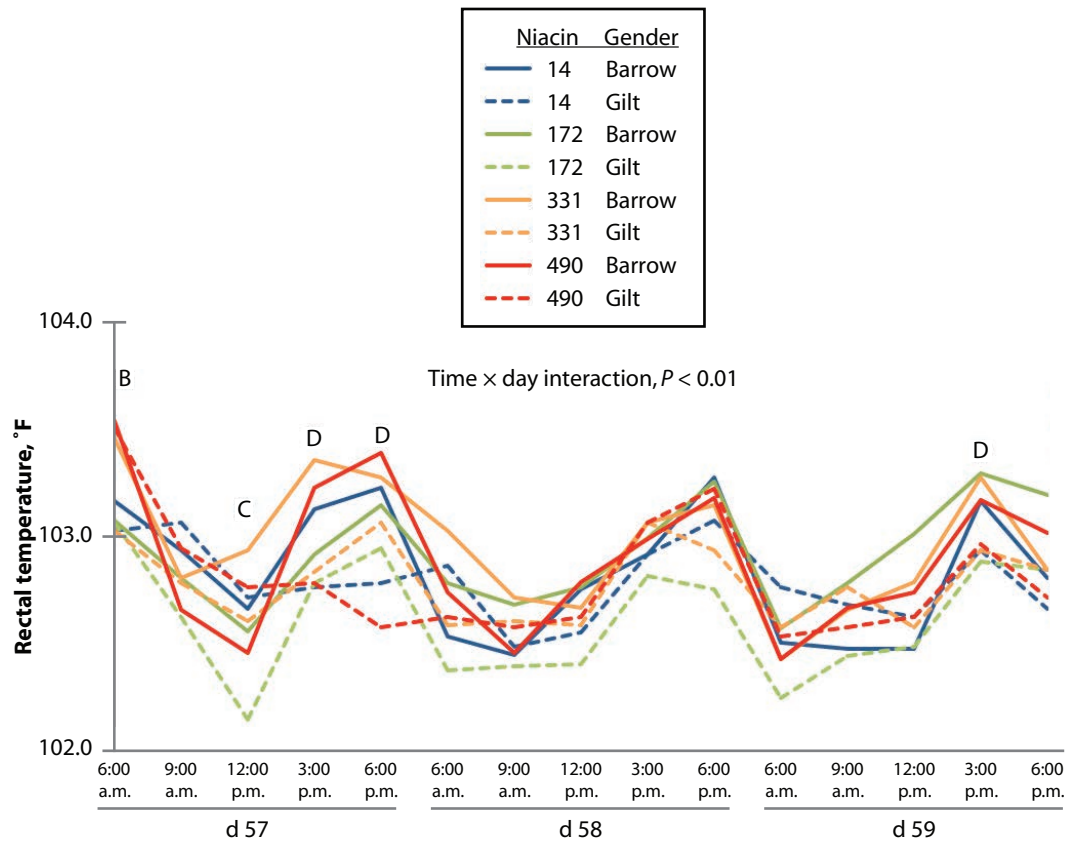


Figure 2. Rectal temperatures (°F) during d 57, 58, and 59 of the study. Temperatures were collected from 1 barrow and 1 gilt per pen. Letters denote differences ($P < 0.05$): B, linear dietary niacin effect; C, quadratic dietary niacin effect; D, gender effect.

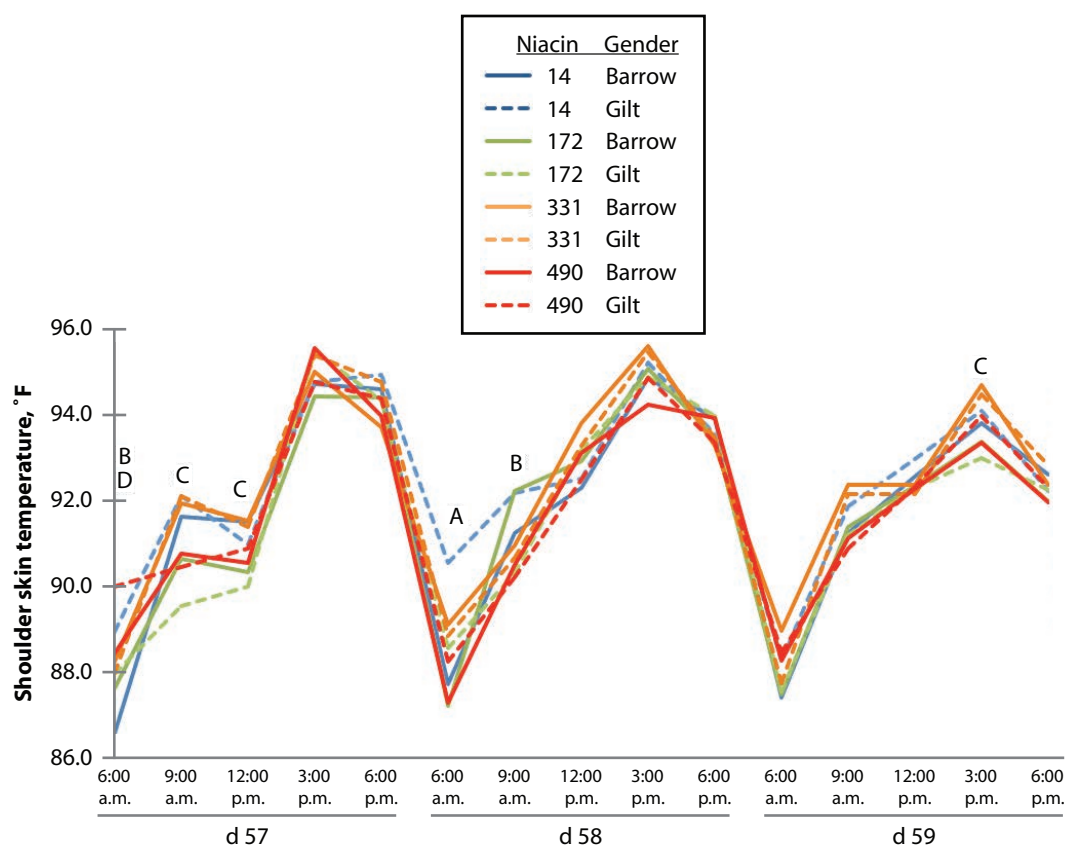


Figure 3. Shoulder skin temperatures (°F) during d 57, 58, and 59 of the study. Temperatures were collected from 1 barrow and 1 gilt per pen using an infrared dual laser thermometer. Letters denote differences ($P < 0.05$): A, dietary niacin $\times$ gender interaction; B, linear dietary niacin effect; C, quadratic dietary niacin effect; D, gender effect.

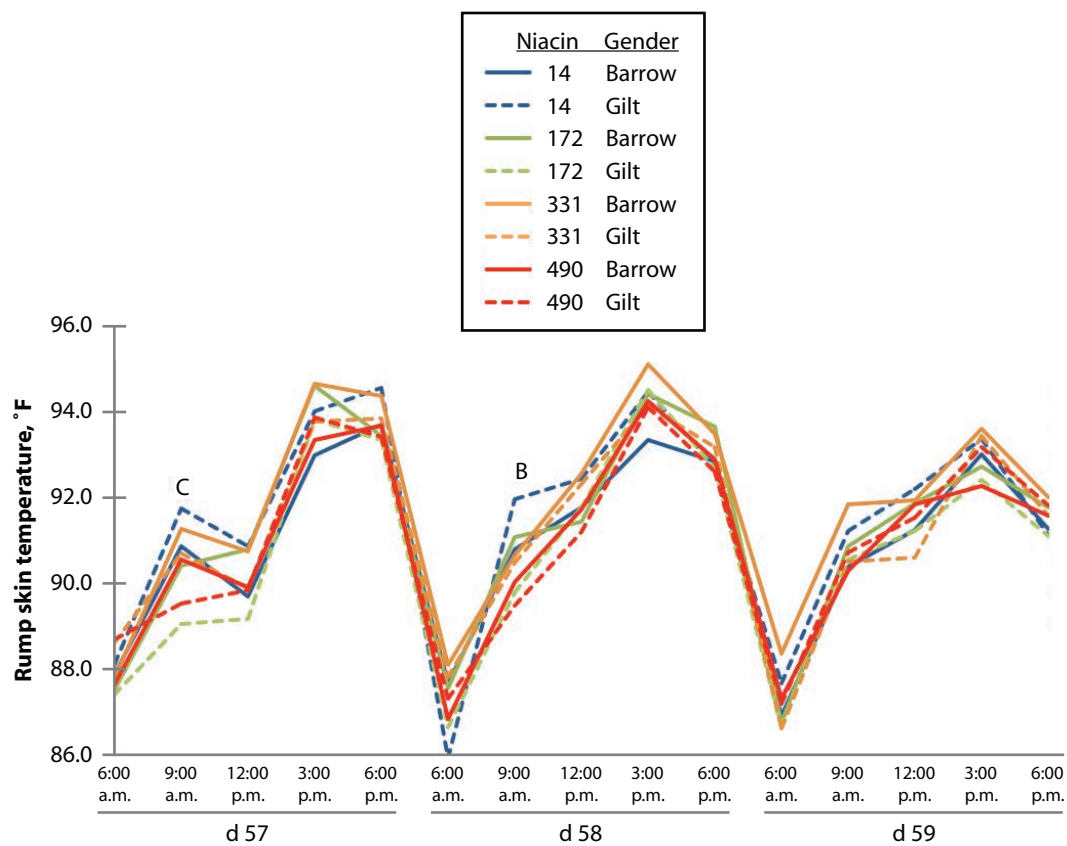


Figure 4. Rump skin temperatures (°F) during d 57, 58, and 59 of the study. Temperatures were collected from 1 barrow and 1 gilt per pen using an infrared dual laser thermometer. Letters denote differences ($P < 0.05$): B, linear dietary niacin effect; and C, quadratic dietary niacin effect.