USE OF INFRARED THERMOGRAPHY TO EVALUATE DIFFERENCES IN MEAN BODY SURFACE TEMPERATURE AND RADIANT HEAT LOSS IN GROWING PIGS

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Summary

Eighty barrows were used in two experiments to determine the relationship between feed intake or dietary energy concentration and mean body surface temperature (MBST) and mean body surface radiant heat loss (MBSL) as measured using infrared thermographic images. In Exp. 1, feed intake level was varied. As expected, pigs with higher feed intake grew faster. The faster growing pigs had higher MBST and MBSL. In Exp. 2, pigs (initially 130 lb) were allotted to one of four dietary energy levels (1,250 ME/lb, 1,360 ME/lb, 1,475 ME/lb, 1,590 ME/lb). Increasing dietary ME levels increased ADG, G/F, ME intake, MBST, and MBSL. These experiments indicate that infrared thermography can detect MBST and MBSL changes in growing pigs caused by changes in dietary intake or energy level.

(Key Words: Infrared Thermography, Dietary Energy, Growing Pigs.)

Introduction

Recent research has indicated that infrared thermography can reliably identify pigs exhibiting a febrile condition following *Actinobacillus pleuropneumoniae* infection. The rise in MBST associated with the febrile state was observed in comparison to nonchallenged controls during an 18 h period of feed withdrawal for both challenged and nonchallenged pigs. Because adaptive responses to disease or stress typically involve feed intake reductions, it is unknown if the elevated MBST associated with the febrile condition would mask the relative reduction in MBST associated with this feed intake reduction when compared to healthy pigs with full feed consumption.

Additionally, different growth rates, changes in feed intake, and dietary nutrient content affect metabolic heat production in healthy pigs. Because of these differences, it may be possible to detect associated differences in MBST and MBSL and relate them to growth performance. Thus, our objective was to measure the changes in MBST and MBSL associated with growth performance in healthy pigs subjected to changes in feed intake or dietary nutrient profile.

Procedures

Eighty crossbred barrows (326 × C22, PIC, Franklin KY) were selected from the Kansas State University Swine Teaching and Research Center. The pigs were housed in individual pens in an environmentally controlled finishing building with mechanical ventilation. Each pen (5 ft × 5 ft with totally slatted flooring) contained a single-hole, dry feeder and a single-nipple waterer. Pigs were blocked at the start of each experiment by initial weight and allotted to dietary treatment. Pigs in all experiments were allowed ad libitum water consumption.

All diets were corn and soybean meal based with added alfalfa meal, wheat midds, or soybean oil within treatment in Exp. 2 (Table 1). Diets were formulated to meet or exceed current recommendations with the exception of dietary ME (Exp. 2). Total and

[1]Food Animal Health and Management Center.

true digestible nutrient values from NRC (1998) were used, allowing similar total Ca:P ratios across treatments in all experiments and similar calculated true digestible lys:Mcal ME ratios across treatments within Exp. 2.

Imaging equipment consisted of a high-resolution, short-wave (3-5 μm), radiometric, infrared thermal imaging camera. Pigs were imaged while standing unrestrained in their pen. Images were taken at a distance of 6 ft perpendicular to the side of each pig. Mean body surface temperature was calculated from an approximately 3,500 pixel image of a 6 H × 10 W inch area from a standard location on each pig. The mean temperature for the area was calculated to compare changes in mean body surface temperature as affected by experimental treatment. In addition, ambient temperatures were measured at each sampling from six locations at pig height equally spaced throughout the room. These ambient temperatures were used to correct the daily MBST of the pigs using an adjustment factor of ± 0.4 per degree above or below 68°F ambient temperature.

Mean body surface radiant heat loss from the pig was calculated from the equation $Qr = Ar\,E\,\sigma\,(Te^4 - Ts^4)$, where Qr = radiant heat exchange; Ar = effective radiant surface area (m^2); E = emissivity (assumed to be 1.0); σ = Stefan-Boltzman constant; Te = average absolute radiant environmental temperature, K; and Ts = average absolute radiant surface temperature, K.

Experiment 1. Eighty barrows (initially 55 ± 6 lb) were blocked by initial weight in a randomized complete block design and allotted to one of four feed-intake levels within each block for 7 d. The feed intake levels were based upon the NRC (1998) maintenance ME estimate of $106 \times BW^{0.75}$ (kg) for growing swine. Pigs were allowed 0.75 × ME of maintenance (MEm), 1.5 × MEm, 2.5 × MEm, and ad libitum access. All pigs were evaluated daily, and feed was provided at 0730. Orts were collected daily to determine net feed intake. Following a 4 d adaptation period to the intake regimens, images were collected three times per day at 0700, 1100, 1900 h on d 5, 6, and 7. These times were chosen to measure changes in body temperature immediately prefeeding, 3 h after feeding, and 10 h after feeding.

Data were arranged in a randomized complete block design. Pigs were blocked by initial weight and were assigned randomly to individual treatments within each block. For analysis of change in mean body surface temperature and heat loss over time, a PROC MIXED procedure with repeated measures and a Satterthwaite error correction was used. The repeated measures model included the treatment effect, the effects of time period, and the treatment × time period interaction. Comparisons between treatments, within sampling times were made when a significant *F*-test for the treatment × time interaction was found. Individual pig was the experimental unit. Periodic samples by pig were used for the repeated measures. An interactive matrix language procedure was used to determine orthogonal linear and quadratic polynomial contrasts for unequally spaced treatments. To determine the approximate ME intake of the ad libitum-fed pigs, their average ME intake during the growth assay period was calculated relative to their individual calculated MEm requirement (ad libitum intake averaged 3.8 × MEm). The average intake relative to MEm then was used to determine the orthogonal contrasts. The orthogonal contrasts measured the effects of feed intake regimen on growth performance, MBSL, and MBST.

Experiment 2. The 80 pigs from Exp. 1 (initially 130 ± 11 lb) were blocked by initial weight in a randomized complete block design and assigned within block to one of four dietary treatments for 20 d. Pens, feed, and water were as described above. Experimental diets were formulated to provide moderately low, slightly low, adequate, and moderately excess (1,250 ME/lb, 1,360 ME/lb, 1,475 ME/lb, 1,590 ME/lb, respectively) daily energy intake levels based upon expected daily feed intake and calculated dietary nutrient content. After reallotment to the new pen and treatments, pigs were allowed to adjust to dietary treatment for 14 d and then imaged on d 14 through 20. Additionally, pigs were weighed and feeder weights were collected on d 14 and 21 to determine average daily gain, feed disappearance, and feed utilization.

Data from Exp. 2 were analyzed in a randomized complete block design. Pigs were blocked by initial weight and were the experimental unit. Initial BW was used as a covariate to control for the effects of different BW changes by treatment during the 2-week adaptation period. Linear and quadratic polynomials were used to determine the effects of increasing dietary energy content on growth performance, MBST, and MBSL.

Results and Discussion

Experiment 1. Linear and quadratic effects were observed for ADG, ADFI, and G/F (P<0.01; Table 2). These effects resulted from the increased growth performance and feed intake observed as calculated daily ME intake increased from 0.75 × MEm to ad libitum consumption. A treatment × time interaction was observed for MBST (P<0.01; Figure 1). This interaction resulted from treatment effects differing by time period. The MBST increased as daily ME intakes increased (linear, P<0.05) at 0700 and 1900. At 1100 h, MBST was lowest for pigs fed 0.75 × MEm versus those fed the other three treatments (quadratic, P<0.05).

Consistent with previous research, our results showed that as the pig increases its growth rate and feed intake, heat production associated with increased digestion and growth processes increases the body temperature and the heat loss to the surrounding environment.

Experiment 2. Increasing dietary energy density from 1,250 kcal ME/lb to 1,590 kcal ME/lb improved ADG (linear, P<0.01; Table 3) and G/F (linear, P<0.05) and tended to affect ADFI (quadratic, P<0.08). Average daily feed intake was lowest for pigs fed 1,250 kcal ME/lb and highest for the pigs fed 1,475 kcal ME/lb. Calculated ME intake per day also increased as dietary energy density increased (linear, P<0.01). Additionally, MBST and MBSL increased as dietary energy density increased from 1,250 kcal ME/lb to 1,590 kcal ME/lb (linear, P<0.01).

Increasing dietary energy density increased MBST and MBSL, similar to our results in Exp. 1, where increased daily feed allowance of a common diet increased MBST and MBSL. The growth performance results are consistent with previous research evaluating the effects of altering feed intake or dietary nutrient profile on the growth performance of growing pigs.

Our results in Exp. 2 further indicate that high-fiber, low-energy diets reduce feed intake and growth performance, but that the pig will adjust its daily feed intake to compensate for more moderate differences in dietary energy content. This regulation of feed intake relative to dietary energy density is apparent by the increased feed intake of the pigs fed 1,360 kcal ME/lb versus pigs fed 1,475 or 1,590 kcal ME/lb diets. Additionally, pigs fed the 1,590 kcal ME/lb diet did not reduce their feed intake as dietary energy increased above 1,475 kcal ME/lb diet. Thus, the higher energy supported higher ADG, leading to a higher G/F in comparison to pigs fed lower energy diets.

Our results suggest that infrared thermography can be used to detect differences in MBST and MBSL of individual pigs associated with feed intake, growth rate, and dietary energy content in more variable environmental conditions than those found with traditional calorimetry chambers. The ability of infrared thermography to detect differences in environments that are not closely controlled indicates that further development of this technology for use in more traditional growth assays, growth modeling, and commercial production situations is possible. Additional infrared thermography applications in swine research and production may allow direct estimates of changes in swine thermoenergetics due to the effects of treatment or environment.

Table 1. Compositions of Diets[a]

		Experiment 2, kcal ME/lb of diet			
Ingredients, %	Exp. 1	1,250	1,360	1,475	1,590
Corn	64.46	32.74	50.20	62.23	56.41
Soybean meal, 46.5% CP	32.53	21.39	26.85	31.59	35.41
Soybean oil	---	---	---	---	5.20
Alfalfa meal	---	30.94	18.10	3.30	---
Wheat middlings	---	13.20	2.50	---	---
Monocalcium phosphate	1.17	0.99	1.21	1.19	1.18
Limestone	1.10	---	0.40	0.95	1.05
Salt	0.35	0.35	0.35	0.35	0.35
Vitamin premix[b]	0.20	0.20	0.20	0.20	0.20
Trace mineral premix[c]	0.15	0.15	0.15	0.15	0.15
Medication[d]	0.05	0.05	0.05	0.05	0.05
Diet Composition,					
Crude Protein, %					
Calculated	20.48	20.02	20.13	20.41	21.15
Analyzed	21.38	22.51	22.87	23.58	23.67

[a]All diets were formulated to contain 0.75% Ca and 0.65% P.
[d]Provided 25 mg tylosin per lb of complete diet.

Table 2. Effects of Feed Intake Regimen on Growth Performance of 55 lb Pigs (Exp. 1)[a]

	Feed Intake Level[b]				
Item	0.75 × MEm	1.5 × MEm	2.5 × MEm	Ad Libitum	SEM
ADG, lb[cd]	-0.02	1.41	1.96	2.58	0.09
ADFI, lb[cd]	1.04	1.90	2.98	3.62	0.09
G/F[cd]	-0.03	0.75	0.67	0.70	0.04

[a]Eighty pigs (initially 55 ± 6 lb) were blocked by initial weight and allotted in a randomized complete block design. Results are the means of a 5 d growth assay.
[b]Metabolizable energy per day for maintenance calculated as 106*kg $BW^{.75}$.
[c]Linear treatment effect (P<0.01).
[d]Quadratic treatment effect (P<0.01).

Table 3. Effects of Dietary Energy Regimen on Growth Performance, Mean Body Surface Temperature, and Mean Body Surface Radiant Heat Loss of 130 lb Pigs (Exp. 3)[a]

	Dietary Energy, ME/lb[b]					Probability (P<)	
Item	1,250	1,360	1,475	1,590	SEM	Linear	Quad.
ADG, lb	2.36	2.51	2.73	2.82	0.13	0.01	0.76
ADFI, lb	6.44	7.25	6.86	6.90	0.22	0.31	0.08
G/F	0.37	0.35	0.39	0.41	0.02	0.05	0.39
Calculated ME intake, Mcal/d	8.03	9.88	10.10	10.96	0.33	0.01	0.12
MBST, F[c]	89.8	90.5	90.7	91.0	0.29	0.01	0.33
MBSL, kcal/h[c]	-67.2	-70.7	-73.0	-74.8	1.10	0.01	0.34

[a]Eighty pigs (initially 130 ± 11 lb) were blocked by initial weight and allotted in a randomized complete block design.
[b]Calculated values from the NRC (1998) were used for dietary ME content.
[c]Initial BW was used as a covariate in this analysis.

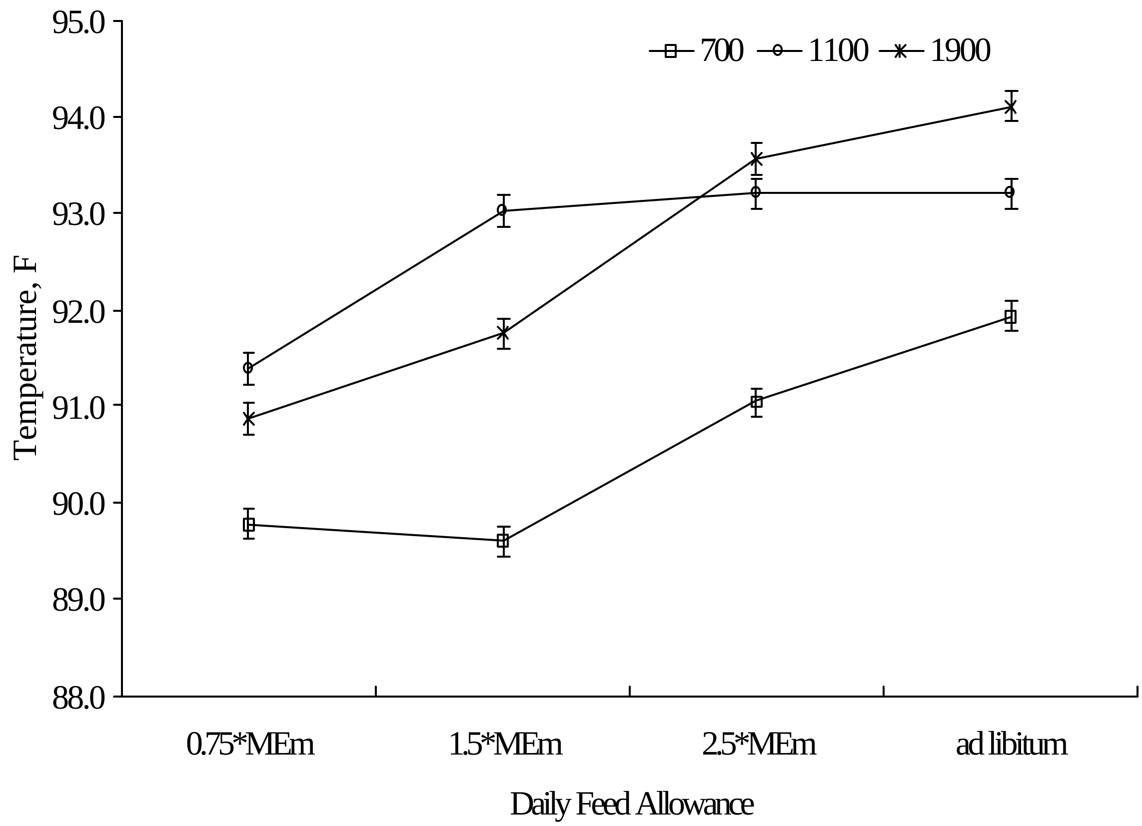

Figure 1. Effects of Daily Feed Allowance on Mean Body Surface Temperature of 55 lb Pigs. Restricted-fed pigs were fed at 0730 daily.