Evaluation of the Thermal Needs of the Early Weaned Pig

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Summary and Implications

The thermal needs of early weaned pigs were examined by placing pigs that were weaned from 13 to 16 days in indirect calorimeters and exposing them to four different temperature regimes. Pigs, in groups of ten (3 $ft.^2$/pig), were weaned into four chambers at 88, 84, 80, and 76°F and the temperature decreased by 2°F per week for three weeks post-weaning. The feed efficiency and average daily gain during the three week trial for the four chambers were 1.30, 0.79 lb./day; 1.33, 0.84 lb./day; 1.38, 0.81 lb./day; and 1.27, 0.81 lb./day, respectively. Overall feed efficiency was significantly different between some of the treatments but average daily gain was not ($P<0.05$). The average moisture production was: 0.485, 0.426, 0.413 and 0.385 lb. H_2O/100 lb.-hr., respectively. The total heat production and sensible heat production was: 8.56, 3.42; 8.76, 4.19; 9.02, 4.66; and 9.08, 4.98 Btu./hr.-lb., respectively. Respiratory quotient averaged 0.95 to 0.96 in each trial. All energetic responses but respiratory quotient had significant differences between treatments. Energetic responses of this study were substantially higher than those currently used for swine nursery design.

Introduction

Most research on the thermal needs of piglets have been investigated for either neonatal piglets or on three week old pigs. However, early weaned pigs are generally weaned at an average age between 14 and 19 days. A few studies do exist, however, on pigs weaned at this age but not necessarily possessing the characteristic growth of segregated early weaned (SEW) pigs.

Many different temperature recommendations exist. Aherne et al. (1993) reported that early weaned pigs, eight to 12 lb., require a temperature of 85°F with a daily variation of less than 4°F for the first week, while pigs 12 to 17 lb. should be kept at 80°F. Murphy et al.(1995) recommended that one week old pigs be started at 90°F and decreased by 1°F every day after the fifth day post-weaning and continuing until 75°F is reached. He also recommend that room temperature may be set lower than 90°F if an effective temperature of 90°F is achieved using hovers and localized heating. Clark (1994) recommended that early weaned pigs be started at 84°F and the temperature decreased 2°F every week.

This wide variety of opinions on temperature is due to several factors. Most studies on lower critical temperatures were conducted 10 years ago or more. Since that time the dietary needs of the early weaned pig have been better defined and met; the genotype of pigs has changed due to the demand for leaner carcasses, and segregating of piglets gives them a faster growth rate. Early weaned pigs, which are high health pigs, may actually have a higher heat production rate, and therefore a reduced lower critical temperature, than conventionally produced pigs due to increased feed consumption and growth. Because of these changes, and the inconsistency in recommendations, further determination of the thermal environment is necessary.

Another consequence of producing segregated early weaned (SEW) pigs is the changes in energetics that affects ventilation system design. Because SEW pigs tend to grow fast, they may produce heat and moisture at different rates. Current ASAE design standards are based on Ota et al. (1975) and may need to be updated to prevent improper design of SEW nurseries.

The objectives of this study were to:

- examine production parameters of SEW pigs exposed to four different temperature treatments;
- determine the energetic responses to temperature treatments; and
- compare information currently used for ventilation design of nursery pigs with that of SEW pigs.

Materials and Methods

Segregated early-weaned (SEW) pigs between 13 and 16 days of age were used in this study. In the first trial, 11 pigs were placed in each of four indirect calorimetry chambers and 10 were placed in each for the second and third trials. Trials two and three used piglets from the same herd which used PIC[*] C15 sows and 405 boars. Trial one used piglets from a pasture farrowing farm and genetics would be considered below average for leanness. When the pigs arrived at the calorimetry chambers they were assigned to one of four temperature treatments and given two cc vaccinations of strep bac[1] with imugen II[*] and toxivac[2] plus parasuis[*]. Sulmet[3] sodium sulfamethazine 12.5%[*] was used to medicate the water for the first week after weaning. Pigs

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[*] Mention of company or product names is for presentation clarity, and does not imply endorsement by the authors or Iowa State University; nor exclusion of any other products that may also be suitable for application.

[1] Product of Oxford Veterinary Laboratory, Worthington, MN.

[2] NOBL Laboratories, Sioux Center, IA.

[3] American Cyanamid Company, Wayne, NJ.

were kept on test for three weeks to final ages of 34 to 37 days of age.

Temperatures for the four chambers were set at 88, 84, 80 and 76°F for the first week and were decreased by 2°F at the end of each of the next two weeks. Once per week the pigs were weighed and the chambers were cleaned. Feeding was done by hand three or four times per day during the first week and ad lib after. They were fed a standard phase starter diet that was purchased from Carl Akey Feeds* and labeled as: Pig 3000 (for pigs 5 to 10 lb.), Pig 2000 (9 to 12 lb.), Pig 1300 (12 to 16 lb.), A700 (14 to 20 lb.), A300 (20 to 30 lb.) and A150 (over 30 lb.). Diets were not switched at precisely the prescribed interval but generally approximated on-farm practices.

This study was conducted in the Livestock Environment and Physiology (LEAP) Research Laboratory near the Iowa State University campus. The LEAP lab has four indirect calorimetry chambers that are 5 ft. by 6 ft. and have pull plug manure systems below plastic coated woven wire flooring. Temperature was controlled using two electric heaters in each chamber. Air is admitted through a perforated ceiling to establish flow patterns that are essentially still air. Air flow rate, as well as influent and effluent oxygen concentration, carbon dioxide concentration, and dewpoint are measured. Each chamber and ambient conditions were measured for six minutes during a 30 minute cycle. The first five minutes allowed the readings to stabilize and the last minute was used to gather data in two second increments and record the average. Total heat production (THP) was calculated based on indirect calorimetry techniques. Moisture production (MP) was calculated from dewpoint readings and air flow. Sensible heat production (SHP) was taken as the difference between THP and the latent heat production calculated from the MP. A more detailed further explanation of the LEAP lab and associated indirect calorimetry calculatations may be found in Xin et al. (1996).

Results and Discussion

Effects of Temperature on Production Parameters

The average total gain for each of the four treatments (from the highest to lowest temperature) were 17.0, 17.5, 16.9, and 17.2 lb./pig. Using an ANOVA test, no significant difference ($P<0.05$) was found in these averages.

Tables 1 and 2 summarize the average daily gain (ADG) and feed efficiency (FE) for each of the trials. A Duncan's test was performed on treatment averages for each week and for the overall ADG and FE for each treatment. ADG overall averages for the four treatments (by descending temperature) were 0.79, 0.84, 0.81, and 0.81 lb./day, respectively. For ADG no significant differences were found between the treatments in any one week or for the overall. FE overall averages were 1.30, 1.33, 1.38 and 1.27, respectively. Results from the Duncan's test indicated that there was no significant difference in overall FE between the 84-80°F treatment (1.33) and the 80-76°F treatment (1.38). There was also no significant difference ($P<0.05$) in the overall FE for all of the treatments but the 80-76°F treatment. Numerically, there appears to be an advantage at the lowest temperature setting (76-72°F treatment) since it possessed the lowest overall FE in two of the three trials but variation within treatments make it undetectable.

Effects of Temperature on Energetics

Table 3 summarizes the overall energetic data. The mean for total heat production (THP) during each week was not significantly different for any of the four treatments. For overall THP, the three warmest and three coldest treatments were not significantly different. The overall THP responses, from the warmest to coldest treatment, were 8.56, 8.76, 9.02 and 9.08 Btu./hr.-lb.

Sensible heat production (SHP), as might be expected, had significant differences for temperature treatments during each week and for the overall. The overall SHP for the four treatments, warmest to coldest, was 3.42, 4.19, 4.66, and 4.98 Btu./hr.-lb. This makes intuitive sense because as temperature drops, the difference between skin temperature and environment temperature becomes greater and the sensible heat production rate becomes greater. The two coldest treatments had SHP that were not significantly different. This may be due, in part, to the fact that as pigs became larger it was difficult to maintain the lower temperatures in the chambers. During the third week of the trials or during hot weather the temperature in these two chambers were actually very close. Therefore, one might expect them to behave similarly. The individual week information may help to define the thermoneutral zone location. Week one had averages at the middle two treatments that were relatively close. Weeks two and three had averages for the coldest two treatment that were relatively close. This may indicate that during week one the lower critical temperature was around 79°F and during the second and third weeks it was around 72°F.

Moisture production (MP) for the warmest treatment in each of the three weeks and the overall was significantly different than the other temperature treatments. This may indicate that the warmest treatment is above the upper critical temperature during each week. Overall average moisture production values for the four treatments, from warmest to coldest, were 0.485, 0.426, 0.413, and 0.385 lb.H_2O/100 lb.-hr. The values decline from the warmest to the coldest treatment, as might be expected. In this case, only the middle two treatments are statistically similar. It should be noted that moisture production was for room calorimetry and includes evaporated moisture.

Respiratory quotient (RQ) is defined as the ratio of CO_2 to O_2 and is an indication of what animals are metabolizing. It also can be used to check an indirect calorimetry system to see that numbers are realistic. RQ exhibited no significant differences between treatments for the individual weeks or overall. It did, however, start off at a lower number which would indicate that pigs were not growing as quickly at first. During the third week the RQ approached 1.0.

The exact location of the thermoneutral zone is not easily determined. However, the results of the energetic portion of this study indicated that the pigs were probably most comfortable and most efficient in a treatment other than the warmest one.

Comparison of Energetics Data to ASAE Standard

Pigs in this study performed much differently than those in Ota et al. (1975), on which the ASAE Standard (1994) was based. Pigs in the Ota et al (1975) study had an ADG of approximately 0.57 lb./day and a FE of 1.65 for a growth period from 8.4 to 31.9 lb. In this study pigs started at approximately 9.5 lb. and finished at 26.0 lb., had an ADG of 0.81 lb./day and a FE of 1.32. This is an increase in ADG of 43% and a decrease in FE of 20%. Pigs in this study were not used over the same weights as Ota et al (1975) so the FE values might actually be closer than 20%. However, ADG gradually increases with increasing animal weight so the comparable ADG could actually be larger than 43% improved. This indicates that in terms of production performance, these were vastly different pigs than were used in 1975.

Differences in energetic data is further evidence of differences in pig performance. Table 4 gives MP, THP and SHP for the ASAE Standard in comparison to this research. The differences in MP are 135 and 73% for the two different animal sizes. This is partly due to the fact that the ASAE Standard excludes water spillage and this study used room calorimetry which would include it. SHP was relatively similar, within 10%, for both animal sizes. The THP based on this study was 55 and 33% greater than the ASAE Standard. This shows that swine being produced today are much different than those produced in 1975. This may be an indication that not only should the ASAE Standard be updated for SEW nursery pigs, but perhaps it indicates that all of the swine data should be examined and updated as needed.

Conclusions

In this study, no significant difference was found in average daily gain or average daily feed intake for segregated early weaned (SEW) pigs exposed to four different temperature treatments and few significant differences were found in the overall FE. However, what was found to be significant was the difference in the production performance and energetics performance of SEW pigs as compared to the ASAE Standard which is used for ventilation design. This difference was significant enough to indicate that perhaps many of the energetic data should be examined.

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Table 1. Average daily gain (lb./day) for SEW pigs beginning at 13 to 16 days of age and ending at 34 to 37 days of age.

Treatment	Week 1	Week 2	Week 3	Overall
88-84°F				
Trial 1	0.59	0.97	1.03	0.86
Trial 2	0.53	0.92	0.97	0.79
Trial 3	0.53	0.73	1.03	0.77
Average	0.55[a]	0.88[a]	1.01[a]	0.79[a]
84-80°F				
Trial 1	0.66	1.12	0.92	0.90
Trial 2	0.53	0.73	1.28	0.84
Trial 3	0.44	0.75	1.06	0.75
Average	0.55[a]	0.86[a]	1.08[a]	0.84[a]
80-76°F				
Trial 1	0.57	0.97	0.88	0.79
Trial 2	0.48	0.86	1.21	0.81
Trial 3	0.42	0.81	1.19	0.81
Average	0.48[a]	0.88[a]	1.06[a]	0.81[a]
76-72°F				
Trial 1	0.59	1.01	0.90	0.84
Trial 2	0.51	0.66	1.17	0.77
Trial 3	0.53	0.84	1.25	0.86
Average	0.55[a]	0.84[a]	1.10[a]	0.81[a]

Column means with different letters for each temperature treatment are significantly different ($P<0.05$).

Table 2. Feed efficiency for SEW pigs beginning at 13 to 16 days of age and ending at 34 to 37 days of age.

Treatment	Week 1	Week 2	Week 3	Overall
88-84°F				
Trial 1	1.00	1.53	1.66	1.49
Trial 2	1.01	1.18	1.22	1.16
Trial 3	1.06	1.28	1.33	1.25
Average	1.02[a]	1.33[a]	1.40[a]	1.30[a]
84-80°F				
Trial 1	1.01	1.45	1.91	1.51
Trial 2	1.00	1.38	1.22	1.22
Trial 3	1.16	1.25	1.31	1.26
Average	1.06[a]	1.36[a]	1.48[a]	1.33[a,b]
80-76°F				
Trial 1	1.03	1.44	1.88	1.50
Trial 2	1.07	1.17	1.42	1.33
Trial 3	1.39	1.39	1.24	1.32
Average	1.16[a]	1.33[a]	1.51[a]	1.38[b]
76-72°F				
Trial 1	1.03	1.39	1.68	1.41
Trial 2	1.04	1.26	1.20	1.18
Trial 3	1.12	1.15	1.29	1.21
Average	1.06[a]	1.27[a]	1.39[a]	1.27[a]

Column means with different letters for each temperature treatment are significantly different ($P<0.05$).

Table 3. Energetic responses for SEW pigs beginning at 13 to 16 days of age and ending at 34 to 37 days of age.

Treatment	THP	SHP	MP	RQ
88-84°F	8.56[a]	3.42 [a]	0.485[a]	0.96[a]
84-80°F	8.76[a,b]	4.19 [b]	0.426 [b]	0.95 [a]
80-76°F	9.02 [a,b]	4.66 [c]	0.413 [b]	0.96 [a]
76-72°F	9.08 [b]	4.98 [c]	0.385 [c]	0.95 [a]

Column means with different letters for each temperature regimen are significantly different (P<0.05).
THP - Total Heat Production (Btu./hr.-lb.)
SHP - Sensible Heat Production (Btu./hr.-lb.)
MP - Moisture Production (lb. H2O/100 lb.-hr.)
RQ - Respiratory Quotient

Table 4. Comparison with ASAE Standard design data.

	8.8 to 13.2 lb. @ 84°F			13.2 to 24.2 lb. @ 75°F		
	ASAE Standard	This Study	Difference	ASAE Standard	This Study	Difference
MP (lb./100 lb.-hr)	0.17	0.40	135 %	0.22	0.38	73 %
THP (Btu/hr-lb.)	5.1	7.9	55%	7.0	9.3	33 %
SHP (Btu/hr-lb.)	3.4	3.7	9 %	4.8	5.3	10 %