Thermal Performance of a Hoop Structure for Finishing Swine

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ASL-R1391

Summary and Implications

The hoop structure temperature response indicated that it did provide a 6 to 8°F temperature increase over the outside temperature during winter. Additional comfort could be provided by using straw or equivalent bedding. Summer temperature performance indicated only a slight increase in temperature over outside. These results suggest that starting pigs weighing less than 40 lbs. would probably be ill-advised during winter months. Additional information needs to be gathered on pig performance and other costs parameters to help farmers make informed decisions on the type of structure to use for finishing.

Introduction

Swine producers often look for low cost structures to raise swine. Producers use pasture systems, cargill units, modified open front buildings, and curtain-sided finishing buildings to feed swine to market weight. Another technology, low cost buildings referred to as "hoops," is now being used as well. These hoop buildings generally use treated wood posts and siding up to a height of 6 feet. From there, steel tubes are fastened to the top of the posts to form a hoop. The hoop is covered with a UV-resistant polypropylene tarp. Thus far most facilities use earthen floors with bedding except for the feeding area, which generally uses concrete.

Many aspects such as pig performance, labor requirements, building life, bedding costs, and the environmental effects on carcass quality need to be examined. Knowledge of these items will enable farmers to strategically evaluate hoop buildings in comparison to other options. This study is only one portion of the knowledge required.

The objective of this study was to examine thermal characteristics of the hoop building during typical Iowa weather conditions.

Methods and Materials

A 30' by 60' hoop structure, donated by Am-Can, Inc.[1], was located on the ISU Rhodes Research Farm, Figure 1. The structure was oriented with the long axis running northwest-southeast. The northwest end was equipped with a tarp to close during the winter and the southeast end remained open. The feeding area was located in the southeast end with the bedded area in the opposite end.

Figure 1. The hoop structure located on the ISU Rhodes Research Farm.

The structure was instrumented with thermocouples and humidity sensors to evaluate the building environment. The thermocouple temperature sensors were placed approximately 4 feet above the floor at 15, 30, and 45 feet from the northwest end. Humidity sensors were hung in the center of the hoop structure at the 4 foot level. Sensors were also placed outdoors to measure the ambient temperature and relative humidity. Measurements were taken every 30 seconds, averaged, and then recorded every 30 minutes.

Monitoring has continued through two groups of pigs thus far. The first group of 151 pigs entered the structure on November 16, 1995, and was marketed in late February and early March 1996. The second group was placed on April 15, 1996, and was marketed in early August to early September. Both groups were started at weights of approximately 50 to 60 lbs.

Results and Discussion

Average, maximum, and minimum indoor temperatures along with average relative humidity (winter trial only) for the winter and summer trials are presented in Tables 1 and 2, respectively. The temperature used for this average was based on information collected 4 feet over the bedding area in the northwest end. This was done because it was the warmest area. Average relative humidity was based on conditions in the center of the structure. It should be noted that the pigs were growing and therefore produced more heat in each successive month.

[1] 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.

Table 1. Characteristics of the hoop structure during a winter trial.

Month	Indoor Temperature (°F)			Relative Humidity (%)
	Average	Maximum	Minimum	
Nov '95	35.3	62.7	11.9	69.4
Dec '95	37.8	63.1	10.2	79.6
Jan '96	24.8	62.7	- 5.8	83.3
Feb '96	28.0	63.6	-19.5	76.0
Mar '96	30.3	74.2	-2.4	59.4

Table 2. Characteristics of a hoop structure during a summer trial.

Month	Indoor Temperature (°F)		
	Average	Maximum	Minimum
Apr '96	53.1	79.9	31
May '96	60.9	88.0	43.4
Jun '96	71.8	95.4	46.2
Jul '96	74.4	99.2	55.5
Aug '96	73.5	89.9	57.2

While the average temperature is interesting, little can be concluded based on this measure. For instance, an average of 60°F in a facility could mean that the temperature varied between 58° and 62 °F or it could mean it varied from 20° to 100 °F. A better measure of the effectiveness of a shelter is the measure of the environmental improvement gained by it use. Figures 2 and 3 illustrate this point. The bar graphs show that during the coldest portion of winter, the hoop was 6° to 8 °F warmer than the outside temperature. The average difference was calculated by subtracting the outside temperature from the inside temperature for each 30-minute average and then averaging them. The value in March was less than 5 °F but this was most likely because the structure was opened up more during warmer days and therefore, operated at a temperature closer to ambient.

The average temperature difference between inside and outside was around 2° to 4°F during most of the summer trial. This is due to the open nature of the building in the summer. The hoop shelter acts essentially as a shade during the summer. This may not have been the case if the tarp material used had been black rather than gray because a black tarp would have absorbed a great deal of heat and created more of a heat stress situation. Temperature difference may also have been greater if the hoop had been longer than it was. A hoop of 100 feet, for instance, would not allow air exchange to occur as easily.

Figure 4 illustrates temperatures in different locations of the structure on one of the colder days during the trial. As can be seen, the northwest end is almost always the warmest place in the structure. On this particular day, the indoor temperature averaged nearly 16 °F warmer than the outdoor temperature but it averaged only -4 °F. The hoop shelter did offer protection but the environmental conditions were poor enought that feed efficiency undoubtedly suffered, even considering the bedding provided additional thermal comfort. Pigs were approximately 4.5 months old at the time illustrated in Figure 4. If smaller pigs had been in the hoop that day the temperature increase would have been smaller. Pig performance would indicate the degree to which they were affected. That, however, is not the focus of this paper and will be presented elsewhere.

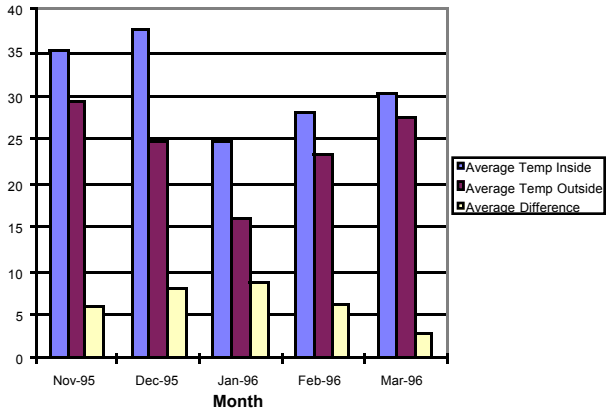

Figure 2. Average temperatures inside and outside the hoop structure with the average temperature difference for the winter trial period.

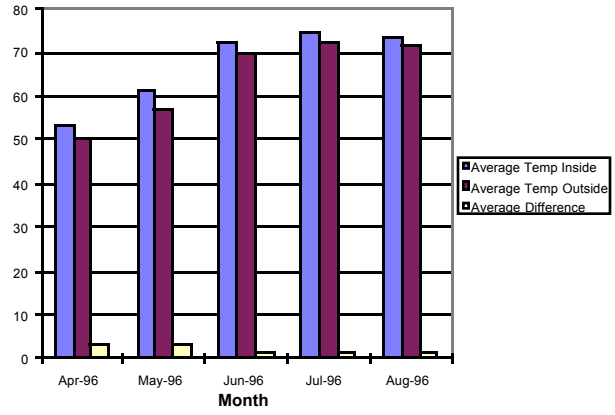

Figure 3. Average temperatures and temperature difference for the summer trial period.

Figure 5 illustrates the temperature response of the hoop building during the summer. The temperature tends to follow the outdoor temperature closely throughout the day. On this particular day the temperature peaked around 1:30 pm. The peak temperature inside lagged several hours most probably due to heat storage within the building. In this case the temperature appeared to be fairly uniform throughout the structure. Pigs present at the time were approximately 4 months old.

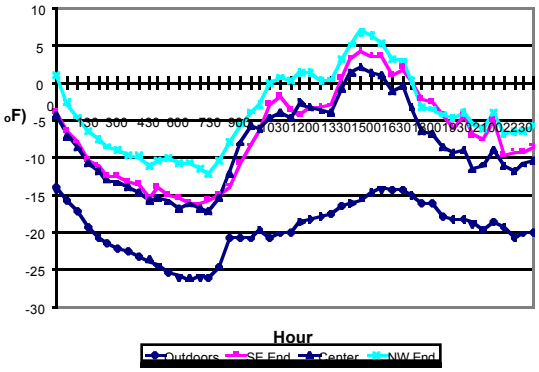

Figure 4. Temperature performance in a hoop structure on February 2, 1996.

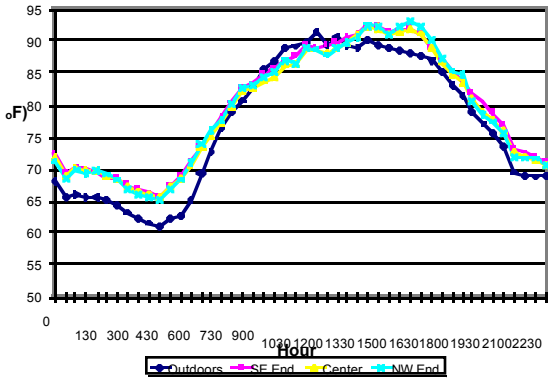

Figure 5. Temperature performance in a hoop structure on June 14, 1996.