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ENVIRONMENTAL AND PRODUCTION PERFORMANCE OF DEEP-BEDDED AND CONCRETE FLOOR HOUSING SYSTEMS FOR GROW-FINISH SWINE IN BRAZIL

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ABSTRACT

Brazil is the 4th largest swine producer in the world, and it has been a challenge to Brazilian producers find ways to manage and appropriately dispose manure generated, especially in the highly intensive production areas located in the southern part of the country. Predominant floor systems include partially and fully slotted floors as well as solid concrete floors. Therefore the manure is usually handled as liquid, requiring large storage structures and eventual treatment, which may be costly to the average swine producer. The Brazilian Livestock Research Company (Embrapa, SC, Brazil) has been investigating the use of organic bedding systems and their effect on thermal environment, air quality, manure management and animal performance. This research was conducted during 17 weeks with animals weighing between 25 and 120 kg in three identical buildings measuring 12.0 x 10.0 m, with four pens in each building. Three different treatments were investigated: (wood shavings and rices hulls for litter versus a concrete floor). The following parameters were evaluated: black globe temperature index, relative humidity, ammonia concentration, weight gain, feed consumption and feed conversion. Statistical analysis includes analysis-of-variance and regression. Results indicated no significant differences between treatments for thermal environment parameters at the 5% level, but high ammonia levels were observed in the bedding system as compared to the concrete floor system. In general animals presented similar values of daily weight gain, feed consumption and feed conversion.

KEYWORDS: Swine, deep bedded, thermal environmental, performance, ammonia.

INTRODUCTION

Intensive swine production in confinement provides an increasingly large source of income and jobs for the rural communities and continues to grow in Brazil. The intensive swine production in Brazil is made possible by the technological advancements in nutrition, genetics, management and environmental control. According to statistics from the Brazilian Association of Swine Productions (BASP, 2003), about 28 million or 2.29 million tons of hogs were marketed in Brazil in 2002, making Brazil the fourth largest swine producing country in the world (Association of São Paulo of Swine Production, APCS, 2003). The southern area of Brazil constitutes the center of swine production, accounting for nearly half of the total production.

The challenge for any swine production is to meet the demand of environmental sustainability while providing the animals the quality physical environment for enhanced well-being and thus productivity (Oliveira, 2000). The traditional housing system for intensive grower-finisher swine production typically used in Brazil features open sidewalls, solid or partially slatted concrete floors, and manure-flushing gutters. Such a system requires a large amount of water, which is in increasing shortage of supply, and storage capacity for the liquid manure. Land application of liquid manure poses another potential environmental threat on water quality and air quality through runoff, evaporation (odor, gases) or over-application. Transporting of the manure from the production site to the crop land adds another requirement for the proper machinery and distribution equipment (Oliveira, 2000).

The continued effort to address the environmental and animal welfare issues have led to a growing interest in exploring alternative housing systems in swine productions (Brumm et al., 1997; Gentry et al., 2001). One such alternative production system is the bedded flooring (wood shaving, sawdust, or straw) system. This system provides certain flexibility for the animals to select and modify their own microenvironment (Hill, 2000), especially during cold weather. Other major advantages include much reduced initial investment for the facility, lesser demand for water, and conversion of liquid manure handling to solid manure handling (Oliveira, 1999).

The Swine and Poultry Research Division of EMBRAPA was the pioneer in Brazil in studying bedded housing systems for swine production. According to McGlone (1999), pigs raised on bedding showed less cannibalism, less cushion lesions at the slaughter plant, and tended to have fewer respiratory problems than pigs raised on concrete slatted floors. However, few studies have been made in Brazil to evaluate these systems.

The objective of this study was to compare the thermal environment, ammonia level and production performance of grow-finish swine in the traditional slatted concrete floor system, a bedded system with wood shavings on top of concrete floor, or a bedded system with rice hulls on top of concrete floor.

MATERIAL AND METHODS

Experimental Facility and Animals

The study was conducted at the EMBRAPA Swine Research Station in Concordia, Santa Catarina, Brazil during August to November 2002. Three open-sided and naturally ventilated buildings were used, one per treatment of conventional slatted concrete floor, a bedded system with wood shavings, or a bedded system with rice hulls. Each building had four pens (6.0 x 5.0 m each) and shared the same structural characteristics (no roof line insulation) and orientation (fig. 1). There was a 10-m separation distance between the ends of the buildings.

A total of 216 pigs (Landrace x Large White, mixed sex) at an initial body weight of about 25 kg were obtained from the EMBRAPA stock for the study. The animals were acclimated under the same conditions prior to start of the treatment comparison. They were then randomly assigned to groups of 18 per pen or 72 pigs per building. The effective floor space was 1.6 m^2 per pig for the concrete floor pens, and 1.2 m^2 per pig for bedded pens.

Figure 1 – Photographical view of the swine facility used in this study.

Dry-bulb and wet-bulb temperature, air velocity and black globe temperature at 0.40 m above the floor were continuously measured at 10-min intervals with a CR10X data logger (Campbell Scientific Inc., Logan, UT, USA). The measurement points were at the central locations of both the south and north pens and were protected from the pigs. Surface temperature of the concrete floor or the bedding was also taken. Air temperature was measure with type T thermocouples, surface temperature of the floor or bedding was measured with an infrared sensor, and air velocity was measured with a hot wire anemometer. The external climatic data were supplied by a weather station located 100 m from the experimental site. The pigs were weighed five times during the experiment.

<u>Thermal Comfort Index</u>

<u>Black Globe Temperature and Humidity Index (BGTHI),</u>

Black Globe Temperature and Humidity Index (BGTHI) combines the effects of air temperature, RH, incident solar and/or thermal radiation and air speed on the animals. Due to lack of such an index for swine, the BGTHI for dairy cows (Buffington et al. (1981) was used to evaluate the thermal environment and comfort of the pigs in this case, of the form

$$BGHI = T_{bg} + 0.36T_{db} – 330.08 \qquad (1)$$

where

T_{bg} = black globe temperature, °K

T_{db} = dry bulb temperature, °K

<u>Thermal Heat Load (THL)</u>

The Thermal Heat Load (THL) expresses the total radiation received by an animal from its surroundings (i.e., both solar and thermal radiation). It is derived from the Stefan-Boltzman relation, of the following form (Esmay,1974):

$$THL = \sigma.MRT^4 \qquad (2)$$

where:

THL = thermal heat load, $W.m^{-2}$

σ = Stefan-Boltzman contant, $5.67x10^{-8}$ $W.m^{-2}.°K^{-4}$

MRT = mean radiant temperature, °K

The mean radiant temperature (MRT) is the average temperature of the surrounding surfaces and a black globe (Bond and Kelly, 1955), and it is calculated as:

MRT = 100

$$\sqrt[4]{2.51\sqrt{v}(Tbg - Tdb) + (Tbg/100)^4}$$

(3)

where:

v = speed of the air ($m.s^{-1}$);

Tbg = black globe temperature, K; and

Tdb = dry bulb temperature, K.

<u>Ammonia Concentration</u>

Instantaneous measurements of ammonia levels (ppm) were taken at 0.20 m above the floor (animal snout height) throughout the experimental period. It was measured with a portable electrochemical ammonia sensor (GasMan II, Crowcon.) (0 – 50 ppm). The sensor was regularly calibrated with a calibration adaptor/aspirator kit.

Animal Performance

The common performance indicators were used to evaluate the pig performance under each system, including average daily gain (ADG), daily feed intake (DFI), and feed to gain ratio or feed conversion (FC).

Statistical Analysis

For the study of the animals performance, the experiment was set up second an outline of subdivided portions, tends in the portions the treatments (three treatments: wood shaving bed, rice hulls bed and conventional concrete floor) and in the sub-portions the periods (4 periods – days of live) in the assembly entirely casually with 4 replications (pens). For the study of the indexes of thermal comfort, the experiment was set up second an outline of subdivided portions, tends in the portions the treatments (three treatments: wood shaving bed, rice hulls bed and conventional concrete floor) and in the sub-portions the hours in a completely randomized block design, with 5 replications.

Analysis of variance was performed on the thermal environment and performance data. Means of the treatments were compared using Tukey's test at 5% significance level. Moreover, regression analysis was conducted to evaluate the time effect of treatment on the response variables

RESULTS AND DISCUSSION

Thermal Environment

For the observed results can be notice that the system of bed doesn't differ significantly ($p > 0.05$) to the system of conventional concrete floor in relation to the thermal comfort evaluated by BGTHI, THL and RH (relative humidity). That means that the two variables (Hours and Treatment), acted independently on the results of BGTHI, THL and RH.

The diurnal profiles of hourly BGTHI, THL and RH for the treatments are shown in figures 2, 3, and 4, respectively.

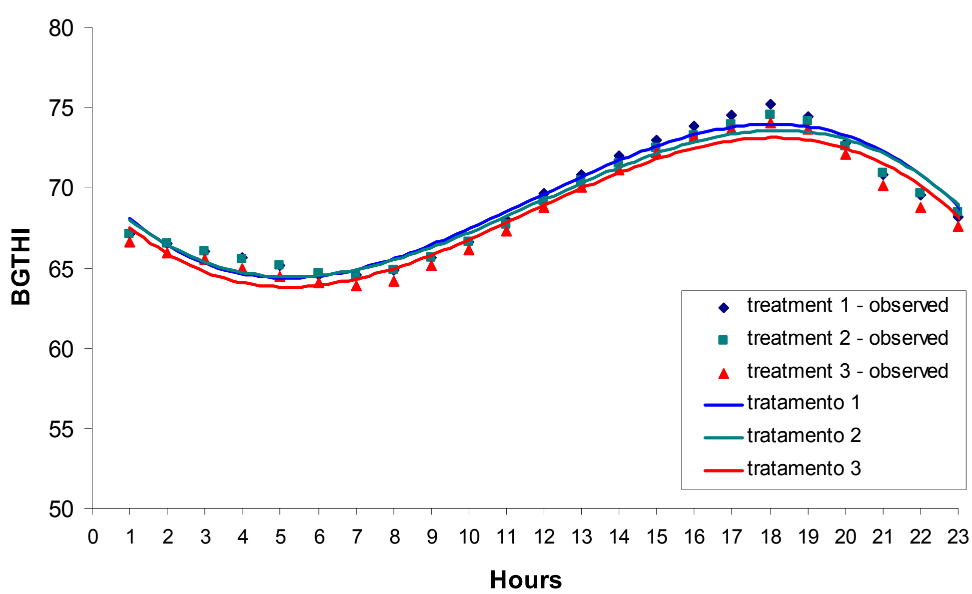

Figure 2 - Mean hourly BGHTI values for the treatment of wood shaving bedding (Treatment 1), rice hull bedding (Treatment 2), or conventional concrete floor (Treatment 3) during the experimental period

As it can be seen from figure 2 that for all the treatments BGHTI was the lowest in the morning, increased gradually with time and reached maximum during 4:00 to 7:00 p.m. This diurnal pattern agreed with the observations previously reported by Rosa (1984), Piasentin (1983), Campos (1986), and Tinôco (1988, 1996, 2001); and followed the solar radiation pattern in the southern hemisphere, as described by Rivero (1986). All three treatments shared very similar BGTHI values and profiles. Similar relationships among the treatments hold in terms of THL and RH values and diurnal profiles. Also shown in figure 4 is the high RH levels throughout the day which is conducive to ammonia generation from litter, as reported by Baiao (1995). The shadow patterns of the inside and outside RH resulted from the open nature of the buildings, typical of swine facilities in Brazil.

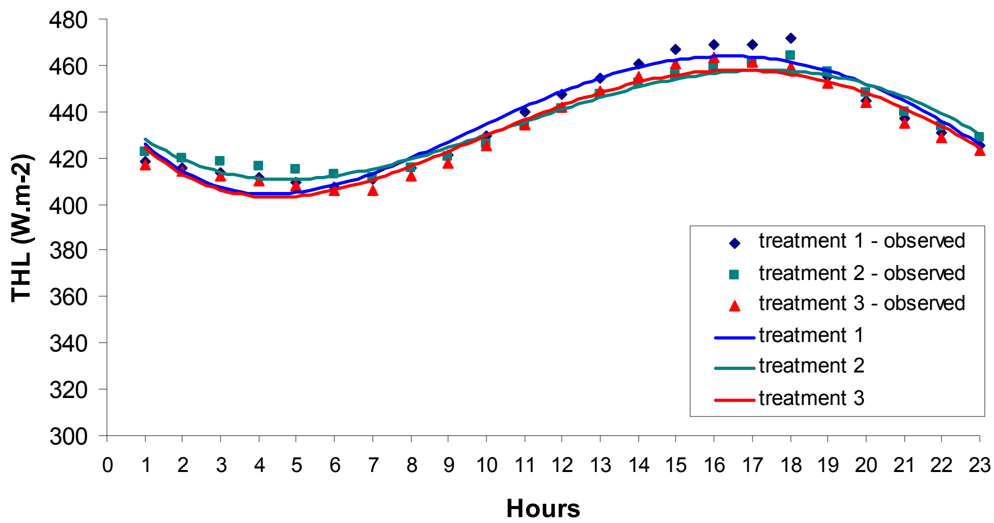

Figure 3 - Mean hourly THL values for the treatments of wood shaving bedding (Treatment 1), rice hull bedding (Treatment 2), or conventional concrete floor (Treatment 3) during the experimental period

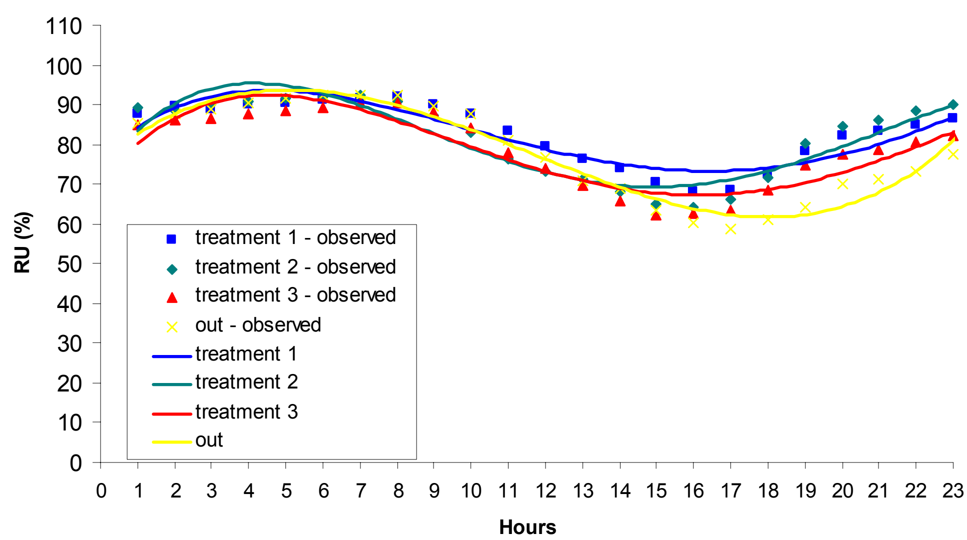

Figure 4 - Mean hourly RH values for the treatments of wood shaving bedding (Treatment 1), rice hull bedding (Treatment 2), or conventional concrete floor (Treatment 3) during the experimental period

<u>Production Performance of the Pigs</u>

In the Table 1 to 3 are presented the medium values for the variables in study. Performance of the pigs was evaluated for four growth stages or periods: 25 to 52 kg (Period 1), 52 to 78 kg (Period 2), 78 to 104 kg (Period 3), and 104 to 118 kg (Period 4).

Table 1 - Average daily weight gain (ADG, kg/d-pig) of the pigs under the three treatments of wood shaving bedding (treatment 1), rice hull bedding (treatment 2) and conventional concrete floor (treatment 3) during each growth period.

Periods	Treatment 1	Treatment 2	Treatment 3
1	0.761Ba	0.770Ba	0.742Ba
2	0.997Aa	0.965Aa	0.931Aa
3	0.746Bb	0.751Bb	0.952Aa
4	0.739Ba	0.629Cb	0.659Bab
Overall	0.810	0.778	0.821

Values followed by the same small letter in the row and capital letter in the column were not significantly different (P>0.05)

Table 2 - Average daily feed intake (DFI, kg/d-pig) of the pigs under the three treatments of wood shaving bedding (treatment 1), rice hull bedding (treatment 2) and conventional concrete floor (treatment 3) during each growth period

Periods	Treatment 1	Treatment 2	Treatment 3
1	1.817Ba	1.833Ca	1.76Ca
2	2.703Aa	2.610Aa	2.509Ba
3	2.577Ab	2.56ABb	2.863Aa
4	2.747Aa	2.383Bb	2.823Aa
Overall	2.459	2.346	2.488

Values followed by the same small letter in the row and capital letter in the column were not significantly different (P>0.05)

Table 3 -Average feed conversion (FC) of the pigs under the three treatments of wood shaving bedding (treatment 1), rice hull bedding (treatment 2) and conventional concrete floor (treatment 3) during each growth period

Periods	Treatment 1	Treatment 2	Treatment 3
1	2.387Ca	2.380Ca	2.371Ca
2	2.711Ba	2.704Ba	2.694Ba
3	3.454Ba	3.408Bab	3.007Bb
4	3.717Ab	3.788Aab	4.283Aa
Overall	3.035	3.015	3.030

Values followed by the same small letter in the row and capital letter in the column were not significantly different (P>0.05)

Significant differences in the performance parameters among the treatments were observed during growth periods 3 and 4. Specifically, in period 3 pigs in the concrete floor system had the greatest ADG (0.95 kg/d vs. 0.75 kg/d), whereas in period 4 the wood shaving/rice hull bedding system and the concrete floor system shared similar ADG; but the wood shaving system showed better ADG than the rice hull bedding system. In period 3 the concrete system had the highest average DFI; and there was no difference between the two bedding systems. In period 4, the rice hull bedding system had the least average DFI; and no difference between the shaving bedding and the concrete floor systems. Finally, the concrete floor and wood shaving system differed in FC in both periods 3 and 4, better FC for the concrete system in period 3 but opposite in period 4

<u>Ammonia Concentration</u>

Figure 5 shows the daily ammonia concentrations under each system. The concrete flooring system had consistently the lowest ammonia levels, whereas both bedded systems shared fairly similar levels. However, these measured values in all the treatments were below the threshold level of 20 ppm as recommended by CIGR (1984) for animal housing.

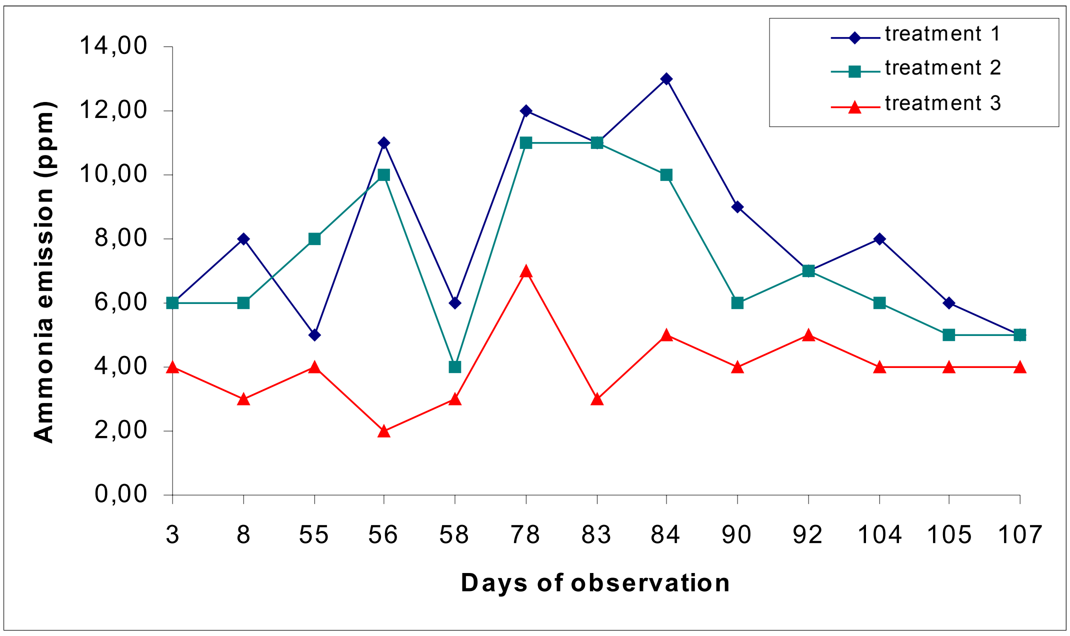

Figure 5 - Ammonia concentrations in the wood shavings-bedded (treatment 1), rice hulls- bedded (treatment 2) and conventional concrete floor (treatment 3) system.

CONCLUSION

- Based on the current study, the following conclusions were drawn:
- The three flooring systems led to the similar thermal environment in terms of the black globe temperature and humidity index (BGTHI), thermal heat load (THL) and relative humidity.
- Pigs under the three flooring systems had similar overall production performance of daily weight gain , feed intake and feed conversion.
- Compared with the concrete flooring system, the bedded systems had higher ammonia concentration, which presumably would lead to higher ammonia emission rate. However, the ammonia concentrations in all systems were well below the suggested threshold (20 ppm) in livestock housing
- Deep-bedding system for grow-finish swine in open buildings under Brazilian climate seems a promising, viable option for the industry. Further tests are warranted to collect more data, particularly concerning the economic and environmental impacts of such systems.

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