Ciência Rural
ISSN: 0103-8478
cienciarural@mail.ufsm.br
Universidade Federal de Santa Maria
Brasil

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Ciência Rural, vol. 39, núm. 3, junio, 2009, pp. 838-843
Universidade Federal de Santa Maria
Santa Maria, Brasil

Ciência Rural, Santa Maria, v.39, n.3, p.838-843, mai-jun, 2009
ISSN 0103-8478

Effects of different litter depths on environmental parameters and growth performance of growing finishing pigs

Efeito de diferentes profundidades de cama usada para suínos em crescimento e em terminação sobre parâmetros ambientais e desempenho de crescimento

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ABSTRACT

Deep litter systems represent low cost alternatives to raise growing-finishing pigs, reducing slurry accumulation, although pig's thermal comfort may be negatively affected by the heat produced inside the litter. This study compared environmental and performance parameters for growing-finishing pigs raised on deep litter systems having distinct depths and on solid floor. The experiment was conducted in a region of temperate climate of Brazil, comparing three treatments: litter having rice husk 0.5m (T1); and 0.25m deep (T2); and solid concrete floor (T3). The first litter was used in two lots and replaced by a second litter used in other two lots, during 52 weeks. Each lot included five pigs in a 7m² pen, from 60 to 145 d of age. Environmental parameters were determined at weekly intervals, including: atmospheric temperature; relative humidity; temperature at the center of the pen, in the surface (TSF); and at half of the depth (THD), only for T1 and T2. Feed consumption and weight of pigs were measured every four weeks. Atmospheric temperature and relative humidity were not influenced by the treatments (P>0.05). Mean TSF was 22.8 ± 3.6ºC, being lower for T3 (P<0.05), but with no difference between T1 and T2 (P>0.05). TSF was higher for new than for used litters (P<0.001) and for the first than for the second litter (P=0.03), apparently increasing in lots raised during termophilic phases. Mean THD was 33.8±10.8ºC, being higher for T1 than for T2 (P<0.05). THD was also higher for new than for used litters (P<0.001) and for the first than for the second litters (P<0.05). No growth performance parameter differed across treatments (P>0.05). Despite the potential unfavorable thermal comfort under high temperatures, deep litter systems can be used to raise pigs in the growing-finishing phases due to the absence of negative effects for growth performance.

Key words: *deep litter systems, environmental comfort, growing-finishing, swine.*

RESUMO

O uso de cama representa uma alternativa de baixo custo para a criação de suínos em crescimento e em terminação, promovendo redução do acúmulo de dejetos, embora o conforto térmico dos animais possa ser prejudicado pelo calor produzido no interior da cama. Este estudo compara os parâmetros ambientais e o desempenho de crescimento de suínos em sistemas de criação sobre cama, com profundidades distintas, e sobre piso concreto. O experimento foi realizado em uma região de clima temperado na região Sul do Brasil, comparando três tratamentos: cama de casca de arroz com 0,5m (T1), com 0,25m de profundidade (T2) e piso de concreto (T3). A primeira cama foi usada em dois lotes de animais e foi substituída por uma segunda, usada em outros dois lotes, compreendendo 52 semanas. Cada lote foi constituído por cinco animais criados dos 60 aos 145 dias de idade, em uma baia de 7m². Os seguintes parâmetros ambientais foram medidos semanalmente: temperatura ambiente, umidade relativa e temperatura no centro da baia, na superfície (TSF) e na metade da profundidade da cama (TMP), apenas em T1 e T2. O consumo de ração e o peso dos animais foram aferidos a cada quatro semanas. A temperatura ambiente e a umidade relativa não foram influenciadas pelos tratamentos (P>0,05). A TSF média foi de 22,8±3,6ºC, sendo menor no T3 (P<0,05), mas sem diferir entre T1 e T2 (P>0,05). A TSF foi mais alta nas camas novas do que nas usadas (P<0,001) e nas primeiras camas em comparação com as segundas (P=0,03), aparentemente sendo mais alta nos lotes criados durante as fases termofílicas. A TMP média foi de 33,8 ± 10,8ºC, sendo mais alta no T1 do que no T2 (P<0,05). A TMP também foi mais alta nas camas novas do que nas usadas (P<0,001) e nas primeiras camas em comparação com as segundas (P<0,05). Nenhum dos parâmetros de crescimento diferiu entre os tratamentos (P<0,05). Ainda que possam ocorrer condições

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Received 02.20.08 Approved 09.23.08

de conforto térmico desfavoráveis aos animais, principalmente sob temperaturas mais elevadas, o sistema de criação sobre cama pode ser usado nos setores de crescimento e terminação sem prejuízo para o desempenho de crescimento.

Palavras-chave: *sistemas de criação sobre cama, ambiência, crescimento, terminação, leitões.*

INTRODUCTION

The structure of the swine production systems in Brazil changed drastically during the last decades. Feedstuffs and other raw materials are now produced far away from the places where the animals are reared (CORRÊA et al., 2000). In such places, the waste accumulated surpasses the ground's absorption capacity, as well as the recommendations for their use as fertilizers, which leads to environmental degradation (JONGBLOED & LENIS, 1998). As a consequence, alternative systems based on assumptions such as low cost, improved animal welfare and reduced environmental impact, have called the attention of swine producers (HONEYMAN, 1996). Deep litter systems have been eventually implemented by Brazilian pork producers (CORRÊA, 2000), especially during the growing and finishing phases, because they facilitate the waste removal with costs lower than those for traditional systems (HONEYMAN, 2005).

Deep litter systems use a 50cm litter composed of carbon rich material, such as sawdust, rice husk or cereal peelings (OLIVEIRA et al., 1999; CORRÊA et al., 2000; GENTRY et al., 2004) instead of conventional concrete or plastic floors. The litter acts not only as floor, but also as digestor for the waste, stocking and stabilizing the slurry inside the facilities, as occurs in composting (OLIVEIRA et al., 1999). While slurry has less than 10% of dry matter, the deep litter system's waste has more than 40% of dry matter, which enhances its agronomic value (WANG et al., 2004). The heat needed for composting is produced during the thermophilic phase, in which the temperature inside the litter may be higher than 40ºC for more than 90d (CORRÊA et al., 2000; TIQUIA, 2005). Thus, raising pigs on deep litter systems, in regions of warm climates or during warmer seasons, may surpass the recommended levels of environmental comfort during the thermophilic phase of composting, which may negatively affect growth performance (CORRÊA et al., 2000). However, data about the use of litters having depth lower than 50cm are not available.

The objective of this study was to evaluate the effect of the depth of the litter on the environmental parameters within a swine finishing facility located in a region of sub-tropical climate and on growth performance during the growing and finishing phases.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Station of the Universidade Federal de Pelotas, Rio Grande do Sul state, Brazil, at 31º45'S latitude and 52º21'W longitude. The animals were housed in a facility 3.2m high, covered with ceramic tiles. Three treatments were compared: rice husk 0.5m deep (T1); rice husk 0.25m deep (T2); and solid concrete floor (T3). Each treatment was applied to a 7m^2 pen with 5 pigs, including a conventional feeder and one nipple drinker. Four replicates were conducted over time, consisting of four different lots of pigs: lot 1, from July to September; lot 2, October to December; lot 3, from February to April; and lot 4 from May to July. Two litters were used: the first for lot 1 and lot 2; the second for lot 3 and lot 4. Those litters were manually scarified between the lots.

Each pen included two castrated males and three females (all F1 Landrace x Large White), starting with an average age of 60d and finishing with an average age of 145d. Considering all the four lots, 60 pigs were raised. The pigs were fed *ad libitum* with a 19% crude protein growing diet, having 3350kcal of ME Kg^{-1} and 17% crude protein finishing diet, having 3200kcal of ME Kg^{-1} (NRC, 1988). Feed consumption was registered for each group, considering the difference between the feed supplied during the period and that left at the end of each lot. The pigs were weighted at the 0, 30, 60 and 90d of the experiment, so weight gain during the period was calculated. Feed conversion was calculated per group, by combining data on feed consumption and weight gain.

Environmental parameters were determined at weekly intervals. The litter temperature was measured through a Multi-Stem® digital thermometer, at the center of the pen, both in the surface (TSF) and at half of the depth (THD). For T3, the floor temperature was considered as the TSF, but the THD was measured only for T1 and T2. Atmospheric temperature and relative humidity were determined 70cm above the floor surface for each pen.

The effects of treatments, lots and treatment per lot interaction on environmental parameters were evaluated by ANOVA with repeated measures, considering the lot as the within subject factor, whereas the week of data collection was the subject factor nested within the effect of treatment. Comparisons among means were conducted by the Tukey test. Mean feed consumption, weight gain and feed conversion were compared across treatments and lots by general ANOVA, but interactions were not tested because such parameters were not measured weekly. Orthogonal contrasts were used to compare environmental parameters for the first (lots 1 and 2) and the second litter (lots 3 and 4) and also for the new (lots 1 and 3) and used litters (lots 2 and 4), using the Schefée test. All statistical analyses were conducted with the Statistix® software (2003).

RESULTS AND DISCUSSION

The mean relative humidity during the experiment was equal to 81.1 ± 8.4%. That parameter was not influenced (P>0.05), by the use of deep litter systems or by the litter's depth (Table 1). Relative humidity varied between 60% and 96%, being both extremes registered in lots raised on concrete floor, but no difference was observed across lots (P>0.05) and the values registered throughout the experiment in treatments with and without litter were very close. During most of the experiment, relative humidity values exceeded those recommended by VEIT & TROUTT (1982) and BENEDI (1986) for growing and finishing pigs, respectively.

The mean atmospheric temperature during the experiment was 18.2±4.0°C. As shown in table 1, atmospheric temperatures was not influenced by the treatments (P>0.05) and its values remained within the limits recommended by VEIT & TROUTT (1982) for growing-finishing pigs (12°C to 21°C), but a little higher than those recommended by BENEDI (1986), which would be between 15°C and 18°C. Atmospheric temperature was higher (P<0.0001) for lots 2 and 3 (20.0±0.6°C and 20.1±0.6 °C, respectively) than for lots 1 and 4 (16.0±0.6°C and 16.2±0.6°C, respectively), which were raised during winter and falls months.

Mean TSF during the experiment was equal to 22.8±6.6°C. Generally, TSF was lower (P<0.0001) for T3 than for the litter treatments (Table 1), but no difference was observed between litter depths (P>0.05). Considering the significant treatment per lot interaction (Table 2), the lowest TSF were observed in T3 in both lots 1 and 4 (P=0.04), whereas the highest TSF were observed in both litter treatments in lot 1. Thus, during winter and spring, the surface was colder in pens having concrete floor, but warmer in pens having litters with either depth. Figure 1 shows weekly TSF measures suggesting an effect of the termophilic phases of the composting process, more characteristically in lot 1, but also in lot 3. The fact that this effect is apparently more intense in lot 1 may reflect the effect of the period or season in which those lots were raised. However, these data were not compared statistically because the effect of potential treatments per week interactions were automatically adjusted by the repeated measures design, in which the effect of the week was nested within the treatments. Both Lots 1 and 3 had new litters, which presented higher TSF (P<0.0001) than used litters (Table 3). TSF was also higher (P=0.02) for the first than for the second litters (Table 3). In both lots 2 and 3, raised during spring and summer, respectively, increased atmospheric temperatures were observed, but TSF were apparently higher than those recommended by VEIT & TROUTT (1982) and BENEDI (1986), although they were similar across treatments. Therefore, such temperatures were probably influenced by the atmospheric temperature and not by the heat generated by the litters.

In the litter treatments, TSF was higher than for the concrete floor by at least 6.8°C, but there were no differences between litter depths. Thus, although deep litter systems may impair thermal comfort for growing-finishing pigs, during periods of high environmental temperature, such effect would be similar regardless of litter depths. During the thermophilic phase of lot 1, TSF varied from 17ºC to more than 30ºC for T1 and T2, but dropped to nearly 10ºC in lot 3 (Figure 1). During this phase in lot 1, the highest TSF achieved in the litter treatments were 35ºC for T1 and 45ºC for T2, between weeks 5 and 11, whereas the temperatures inside the litter reached nearly 60ºC, indicating that the

Table 1 - Relative humidity, atmospheric temperature and temperature in the surface at the center of the pen and at half of the depth by treatment (n=52)[1].

Treatment	Relative humidity (%)	Atmospheric temperature (°C)	TSF (°C)	THD (°C)
Litter 0.5m deep	81.4	18.5	26.1[a]	35.7[a]
Litter 0.25m deep	81.2	18.4	24.5[a]	31.9[b]
Solid concrete floor	80.6	17.8	18.0[b]	-
SEM	1.2	0.5	0.7	1.8

[1]TSF: temperature in the surface at the center of the pen; THD: temperature at half of the depth.
[a,b]Means having distinct superscripts in rows differ by at least P<0.05.

Table 2 - Temperature in the surface at the center of the pen by lot and treatment (n=39).

Treatment	----------Lot[1]----------			
	Lot 1	Lot 2	Lot 3	Lot 4
Litter 0.5m deep	28.7 ± 1.1[ab]	25.2 ± 1.1[abcde]	28.1 ± 1.1[abc]	22.4 ± 1.1[cdef]
Litter 0.25m deep	30.1 ± 1.1[a]	23.3 ± 1.1[bcde]	25.6 ± 1.1[abcd]	19.0 ± 1.1[efg]
Solid concrete floor	15.3 ± 1.1[g]	19.9 ± 1.1[defg]	20.6 ± 1.1[defg]	16.1± 1.1[fg]

[1]Lot 1: 06-09/2003; Lot 2: 10-12/2003; Lot 3: 02-04/2004; Lot 4: 05-07/2004.
[a,b,c,d,e,f,g]Means having distinct superscripts in rows differ by at least P<0.05.

litter allowed an efficient heat dissipation. The highest TSF observed during the experiment occurred in lots 1 (for T1 and T2) and 3 (for T1), when new litters were under the thermophilic phase, with great heat release due to an intense microbial activity (TIQUIA et al., 1997; KAPUINEN, 2001; VENGLOVSKY et al., 2005). For the same reason, THD was also higher (P < 0.0001) for new than for used litters (Table 3). Mean THD throughout the experiments was 33.8±10.8ºC, being higher (P<0.05) for T1 than for T2 (Table 1). THD for lots 1 and 3 (40.0±1.4 and 38.8±1.4, respectively) were higher (P<0.05) than for lots 2 and 4 (30.9±1.4 and 25.5±1.4, respectively), with no further differences observed across lots or treatment per lot interaction (P>0.05). THD was also higher (P=0.03) for the first than for the second litters (Table 3). The increased temperature inside the litter may influence the behavior of growing-finishing pigs, since they generally lay down on the floor during 60% to 80% of the time, keeping 10% to 20% of their total body surface in contact with the floor (OLIVEIRA et al., 1999). Even though the highest THD generally occurs during the thermophilic phase (KAPUINEN, 2001; TANG et al., 2004), as confirmed in the current study, the heat generated by the composting process was not enough to change the atmospheric temperature and the TSF, although it is likely an indicator of an increased microbial activity, since the THD is positively correlated with waste degradation by the microorganisms involved in the stabilization process (TIQUIA, 2005).

Means for feed consumption, weight gain and feed conversions were: 170.2±6.0kg; 68.7±1.4kg; and 2.5±0.1, respectively. Feed consumption did not differ (P>0.05) for T1 (170.3±1.5), T2 (168.3±1.5) and T3 (172.1±1.5). Weight gain for T1, T2 and T3 was also similar (P>0.05): 67.8±0.8; 69.1±0.8; and 69.1±0.8, respectively. Additionally, no differences (P>0.05) in feed conversion were observed for T1 (2.51±0.1), T2

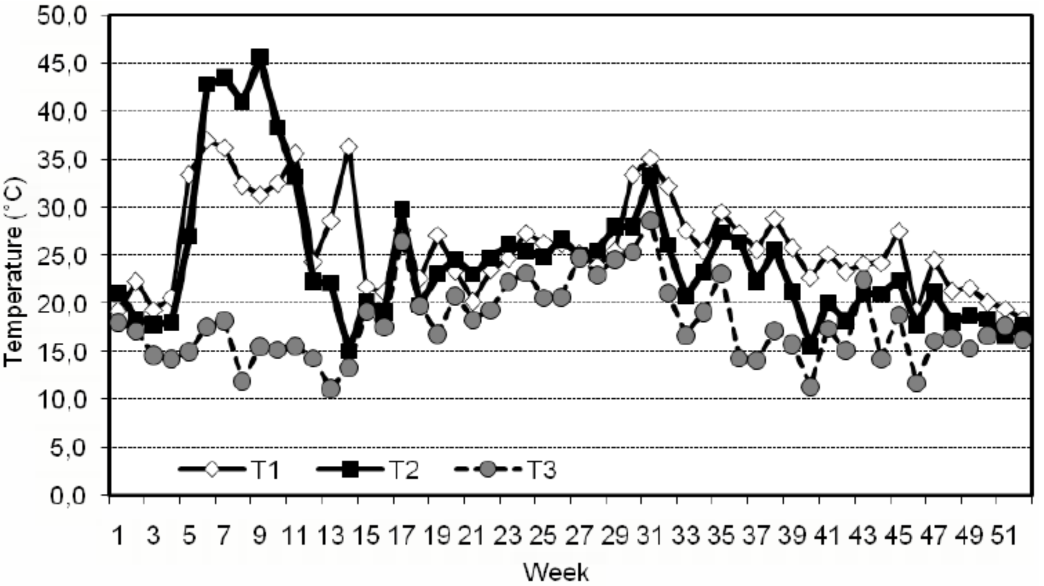

Figure 1 - Temperature on the surface at the center of the floor by lot and treatment. T1: Rice husk 0.5m deep; T2: rice husk 0.25m deep; T3: solid concrete floor. Lot 1: 06-09/2003 – Weeks 1-13; Lot 2: 10-12/2003-Weeks 14-27; Lot 3: 02-04/2004 – Weeks 28-40; Lot 4: 05-07/2004 – Weeks 41-52

Table 3 - Relative humidity, atmospheric temperature and temperature at the center of the pen in the surface and at half of the depth according to the type of litter (n=26)[1].

Parameter	---Litter[2]---					
	First	Second	SEM	New	Used	SEM
Relative humidity (%)	80.2	81.9	1.3	80.0	82.1	1.3
Atmospheric temperature (°C)	18.0	18.4	0.5	18.3	18.1	0.5
TSF (°C)	23.7	22.0	1.0	24.7[a]	20.9[b]	1.0
THD (°C)	35.4	32.2	0.8	39.4[a]	28.2[b]	0.8

[1]TSF: temperature in the surface at the center of the pen; THD: temperature at half of the depth.
[2]First: Lot 1 (06-09/2003) and Lot 2 (10-12/2003); Second: Lot 3 (02-04/2004) and Lot 4 (05-07/2004); New: Lot 1(06-09/2003) and Lot 3 (02-04/2004); Used: Lot 2 (10-12/2003) and Lot 4 (05-07/2004).
[a,b]Means having distinct superscripts differ by at least P<0.05.

(2.44±0.1) and T3 (2.49±0.1). No differences in growth performance were observed across lots (P>0.05). The feed conversion rates were within levels considered acceptable for growing-finishing pigs (MORRISON et al., 2003). Those findings are in agreement with those of CAMPBELL et al. (2003), although CORRÊA et al. (2000) reported lower performance for growing-finishing pigs raised on deep litter systems than for those raised on concrete floor. Generally, pigs raised under heat stress show lower growth performance than those raised under thermo neutral conditions (RINALDO et al., 2000). These results suggest that raising growing-finishing pigs on deep litter systems would not be detrimental for growth performance.

CONCLUSIONS

Although they provide higher temperature in the surface of the pen, in comparison with solid concrete floor, deep litter systems can be used to raise growing-finishing pigs, since there are no negative effects for growth performance. Environmental parameters were not affected by the depth of the litter, but a litter 25cm deep would be a cheaper alternative in comparison with a 50cm deep litter, considering the positive effects on the dissipation of the heat produced inside the litter.

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