



Effects of coffee husk as floor covering on the behavior of boars

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ABSTRACT - The objective was to evaluate the influence of coffee husks as floor covering on the aspects of animal welfare such as behavioral characteristics, body surface temperature, and salivary cortisol levels of stabled boars. Sixteen boars were housed in individual stalls; eight were maintained in a conventional system with a concrete floor and eight were maintained on a concrete floor lined with coffee husks. The experimental period was 60 days. All animals were filmed two days prior to the start of the experiment, on both the 7th and 60th days after exposure to coffee husks, and finally two days after the removal of the material. During this period, the number of times that the animals ate, drank, stood, sat, lay down, and dug was recorded. Furthermore, both body surface temperature and salivary cortisol levels were measured at the beginning and end of the experiment. The use of coffee husks did not influence body surface temperature. Salivary cortisol levels increased during the experimental period only in the animals maintained on coffee husks. In the morning, the coffee husks decreased the number of times that the animals sat and increased the number of times that they lay down. In the afternoon, the use of coffee husks decreased the number of times that the animals stood, sat, or dug and increased the number of times that the animals lay down. Although coffee husks do not change the behavior of the animals in an expressive way, they should not be used as floor covering for boars.

Key Words: alternative materials, environmental enrichment, industrial waste, salivary cortisol, swine, welfare

Introduction

In recent years, there has been increased concern about welfare in animal production. According to Directive 2008/120/EC, pigs should have permanent access to a sufficient quantity of material that enables manipulation activities (Council Directive 2008/120/EC, 2009). Because of this, several studies have evaluated the use of substrates as environmental enrichment for these animals (Bulens et al., 2015; Holinger et al., 2015; Bulens et al., 2016), but most of them with emphasis on growing-finishing pigs or sows and with little information on boars.

In intensive production systems, boars are generally housed in low-stimulus environments that impose constraints

on the development and expression of normal species-specific behavior. In this situation, animals can perform a variety of undesirable behaviors that are either indicative of reduced welfare or cause poor welfare, which can have a negative impact on their behavior and health (O'Driscoll et al., 2013a; O'Driscoll et al., 2013b). Regardless of physiological age, it is known that pigs can vary their behavioral and physiological reactions largely when exposed to the same stressful situation (Lawrence et al., 1991). Thus, the identification of basic-behavior characteristics that predict the welfare in different categories of pigs is important.

Boars play an important reproductive role, especially on farms that use artificial insemination. It is known that the cortisol increase causes several health alterations, such as infertility and low reproductive efficiency (Tsuma et al., 1996). Currently, the need to minimize the stress levels and, consequently, the cortisol secretion on farm animals is evident. In fact, cortisol has been used as a biological indicator of stress in pigs (Fagundes et al., 2008; O'Driscoll et al., 2013a,b).

To improve the environmental conditions, many materials have been used as environmental enrichment, especially for confined animals (Bracke et al., 2006). For growing pigs, enrichment materials, such as straw,

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may influence the behavioral activities, increasing their explorative and playful behavior and decreasing the oral activities directed at pen mates, alleviating the behavioral problems found in barren housing (Bolhuis et al., 2005). On the other hand, reports indicate that animals can lose interest in such objects after a period of time (Van de Weerd et al., 2006). Also, the excessive temperatures arising from substrate fermentation could have a deleterious effect on animal health (Hötzel et al., 2009). Thus, studies are required to assist producers in choosing appropriate enrichment strategies for breeding animals.

Coffee husks are a coproduct of coffee production that is commonly used as floor covering for animals in some regions of the world. However, this practice has rarely been reported in the literature, especially for boars. The presence of substances in the coffee husk such as caffeine (Colas et al., 2010) could affect animal behavior, since it can facilitate dopaminergic neurotransmission (Solinas et al., 2002). In fact, although with no influence on the physiological parameters of sows, the administration of caffeine reduces the behavior score of laying on belly and increase the sitting position of these animals (Superchi et al., 2016). In addition, it is unknown if the stimuli of the dopamine system induced by caffeine are associated with aggressive behavior in pigs, as observed in humans (Seo et al., 2008).

Recently, Teles et al. (2016) concluded that the use of coffee husks as floor covering worsens the quality of semen. Meanwhile, the effect of this substrate as floor covering on behavior of boars is unknown. Thus, the objective of this study was to evaluate the use of coffee husks as environmental enrichment for confined boars and their influence on the aspects of animal welfare, such as behavioral characteristics, body surface temperature, and salivary cortisol levels of these animals.

Material and Methods

The experiment was conducted on a commercial farm located in Oliveira, Minas Gerais, Brazil (-20.9 latitude and -44.8 longitude), from September to November of 2013. All procedures involved in this study were approved by the local ethics committee on animal use (case number 008/14).

Sixteen boars of commercial lineage (Agroceres, DB, and Genetiporc), between nine and 30 months of age and actively reproducing were used. Animals were housed in a masonry shed in individual stalls (2.75 m long, 2.10 m wide, and 1.30 m high) enclosed with rails. The animals received 2.0 kg of a diet containing 3,265 kcal of metabolizable

energy and 13% crude protein (NCR, 1998) daily. Feeding was divided into two portions that were supplied at 8:00 and 14:00 h. Water was provided *ad libitum* and stall cleaning was performed daily in the morning to remove the excessive excreta. Semen collection was performed twice a week, also in the morning, in a specific room next to the stalls.

Boars were divided into two homogeneous groups according to age. The first group was maintained in a conventional system of concrete floor, whereas the other group was maintained in the same system, but with the floor covered with approximately 3.0 to 4.0 cm of coffee husks. Stalls containing coffee husks were alternated between stalls with conventional flooring material in the same barn. Boards were used between the stalls to prevent passage of material from one stall to the other. Coffee husks were completely replaced every four days, whenever the moisture of the material was considered excessive. The experimental period was 60 days. Throughout the experimental period, animals remained clinically healthy and no abnormal behaviors (Broom and Fraser, 2015) or fever were observed. The temperature and air humidity were measured daily and every 5 min throughout the experimental period by using a DataLogger HT 500 (Instrutherm, São Paulo, Brazil).

The experimental design was a randomized block system (age of boars) with two treatments and eight replicates. Each animal was considered an experimental unit.

The behavioral study was conducted by filming (Sony Alartec Cod346, Alartec, Rio Course - São Paulo, Brazil) the animals at four points during the experimental period. These points were two days prior to the start of the experiment, on the 7th and 60th days after exposure to the coffee husks, and two days after the material was removed (Figure 1). Activities such as eating food, drinking water, standing, sitting, lying down, and rooting were registered every minute during the period between 6:30 and 18:30 h following the focal sampling technique (Altmann, 1974). A total of 720 observations of each boar per day were generated, 330 during the morning and 390 during afternoon. The data were analyzed as percentages of observations.

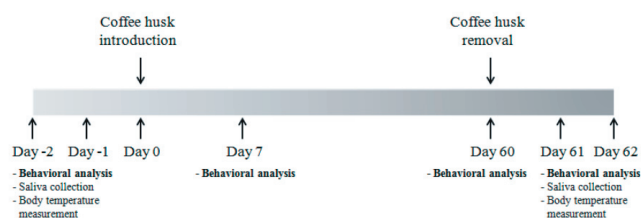


Figure 1 - Flowchart of the experiment.

Body surface temperature was measured at the beginning and end of the experiment (Figure 1), always at 16:00 h (end of the hottest part of the day). Temperature was measured on the palette, shank, and loin of each animal using the FLIR E50 thermal imaging camera (FLIR Systems Inc., Oregon, USA). From each animal, five evaluations were done in different regions of the evaluated body segment. After 5 min, the evaluations were repeated and the means calculated. In cases of value discrepancy, a new evaluation was performed after 5 min.

On the same days, saliva samples were collected for the assessment of cortisol levels. Saliva was collected at 8:00 h using cotton tied to a string that was placed inside the mouth of the swine. The saliva collection schedule was done before the start of animal handling and was based on the findings of Ekkel et al. (1997), in which higher levels of this hormone may be detected. The collection time did not exceed 3 min to prevent possible stress caused by human presence. Afterwards, saliva was extracted from the cotton using pressure, collected in an Eppendorf tube and stored at -80°C until analysis. The cortisol concentration in the saliva was determined by the ELISA method using a commercial kit (Salimetrics, Philadelphia, USA).

The data obtained in the morning and in the afternoon were evaluated separately. Initially, the normality of residuals was tested with the Shapiro-Wilk test. If no significance was observed, analysis of covariance was used. The value obtained on day 0 (start of experiment) for each variable was used as a covariate. For the non-parametric data, averages were compared using the Wilcoxon test. The statistical program Action version 2.4 was used for statistical calculations with $\alpha = 0.05$.

Results

Variations in ambient temperature and relative humidity were observed throughout the day (Figure 2).

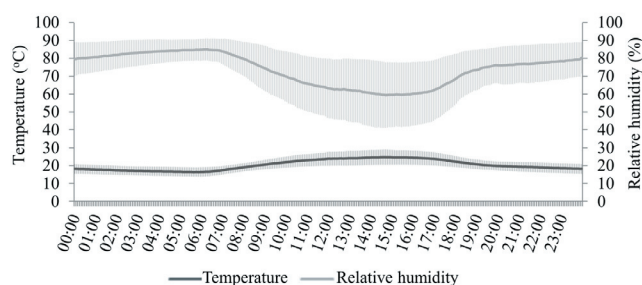


Figure 2 - Ambient temperature and relative humidity (mean \pm standard deviation) throughout the day during the experimental period.

An increase in ambient temperature was observed during the daylight hours (after 6:00 h) with a decrease after 16:00 h. During the morning (6:30-12:00 h), mean values of both ambient temperature and relative humidity were, respectively, $20.78 \pm 3.57^{\circ}\text{C}$ and $73.6 \pm 14.0\%$ and in the afternoon (12:01-18:30 h), $24.21 \pm 3.81^{\circ}\text{C}$ and $61.4 \pm 16.6\%$. Higher oscillations of both temperature and humidity were observed in the afternoon period when compared with the morning.

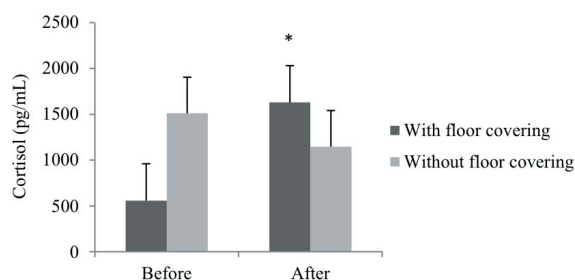
The coffee husk floor covering did not significantly influence the body surface temperature of boars (Table 1). Comparing the experimental groups, the use of coffee husks also did not influence salivary cortisol levels. However, an increase in salivary levels of this hormone was observed throughout the experiment only when coffee husks were used (Figure 3).

During the morning, the presence of coffee husks decreased ($P < 0.05$) the number of times that the animal sat. This effect remained after removal of the material (Figure 4). Within 60 days, the presence of coffee husks increased ($P < 0.05$) the number of times that the animals lay down. This increase disappeared after the removal of the material. The coffee husk floor covering showed no other significant effects on the other behavioral parameters evaluated in the morning.

Table 1 - Average surface temperatures (measured at 16:00 h) of boars maintained in pens with or without coffee husks as floor covering for 60 days

Variable	Floor cover		P-value
	With	Without	
Palette	30.9 ± 1.4	29.6 ± 1.4	0.09
Leg	31.9 ± 3.2	31.4 ± 2.6	0.74
Loin	31.9 ± 2.0	29.2 ± 3.6	0.09

Not significant according to the F test ($P > 0.05$).



The values within time were not significant according to the Wilcoxon test ($P > 0.13$).

* Differ from the beginning (before the use of floor covering) by Wilcoxon test ($P < 0.05$).

Figure 3 - Salivary cortisol levels (mean and standard error) of the boars before and after 60 days using coffee husks floor covering in the stalls.

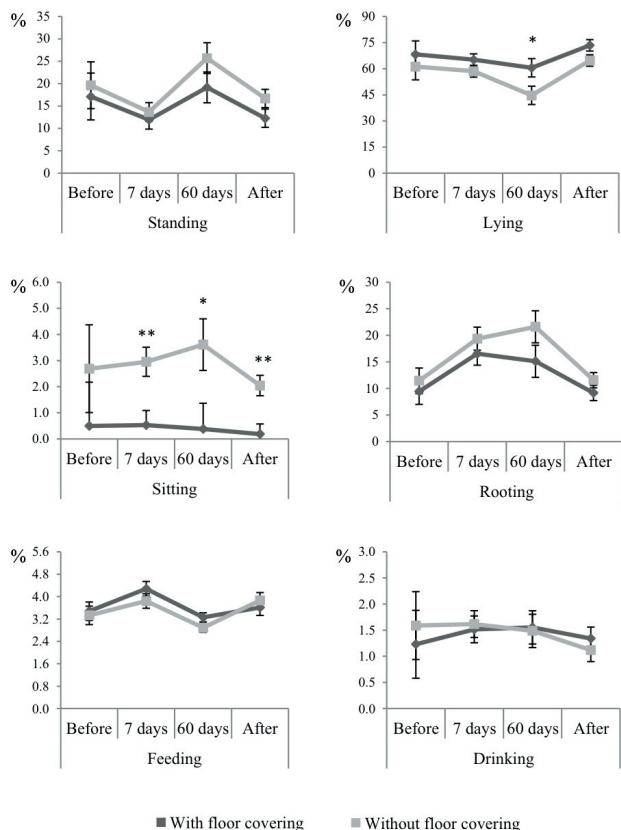
In the afternoon period, the addition of coffee husks decreased ($P<0.05$) the number of times that the animals stood, whereas an increase ($P<0.05$) in the number of times that the animals lay down was induced (Figure 5). These coffee husk-induced changes remained after the removal of the material. Within seven days of use, the animals increased the number of times that they were seated or rooting ($P<0.05$). However, these changes were not further observed after the experimental period. Finally, the removal of the coffee husks was followed by a decrease ($P<0.05$) in both the time that boars remained seated and the frequency with which they drank.

Discussion

The use of certain materials as environmental enrichment is common in the pig industry because of the intensive farming conditions. This is important because the current intensive breeding system includes several stressors

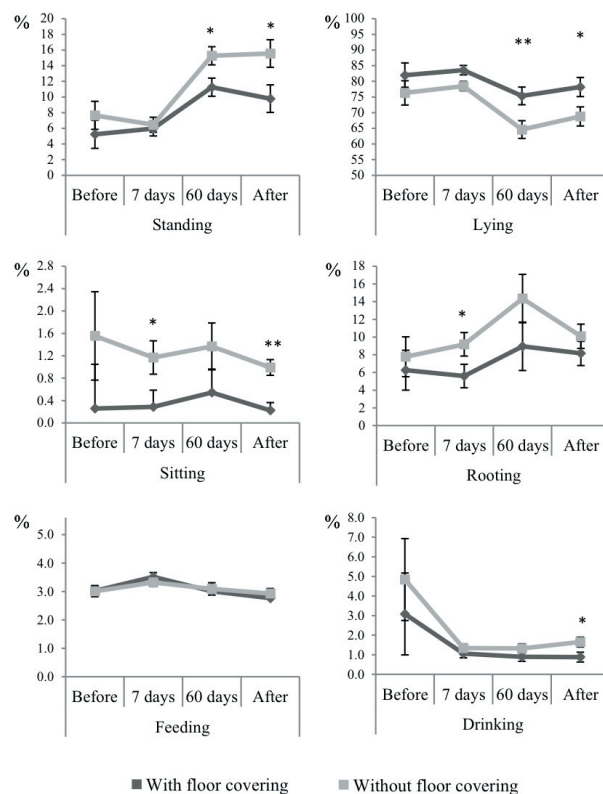
that compromise the welfare of swine that are confined to limited spaces. In this context, environmental enrichment for breeding boars has received little attention from the scientific community. As the enrichment legislation in the EU covers all pigs, these animals also require some form of enrichment (Van de Weerd and Day, 2009).

Several factors can influence the behavior of animals (Broom, 1991; Kunavongkrit and Prateep, 1995); therefore, it is important to observe them in different situations to evaluate their welfare. In the present study, during the morning, beyond differences in air temperature and relative humidity when compared with the afternoon, animal handling activities, such as feeding, cleaning the pens, and semen collection, were performed when contact with humans is also higher. For adult pigs, the ideal relative humidity and ambient temperature range is from 60 to 80% and 13 to 21 °C, respectively (Nienaber et al., 1987; Kunavongkrit and Prateep, 1995). During the afternoon, the ambient temperature was above the recommended



The values are the mean (\pm SEM).
SEM - standard error of the mean.
* $P<0.05$.
** $P<0.01$.

Figure 4 - Morning (6:30-12:00 h) behavior patterns expressed as a percentage of the number of observations (n = 330; relative frequencies) of boars maintained in pens with or without coffee husks as floor covering.



The values are the mean (\pm SEM).
SEM - standard error of the mean.
* $P<0.05$.
** $P<0.01$.

Figure 5 - Afternoon (12:01-18:30 h) behavior patterns expressed as a percentage of number of observations (n = 390; relative frequencies) of boars maintained in pens with or without coffee husks as floor covering.

level and even then the body surface temperature of the animals was not influenced by coffee husks. Probably the animals modified the body posture to compensate the possible difficulty in losing heat by conductive losses, since concrete floor and coffee husks may have different thermal resistance. In some cases, materials used as floor covering could act as thermal insulators, impairing heat exchange between animals and the stall floor. In the case of the present study, the animals kept on coffee husks remained more often lying down and fewer times standing or sitting (Figure 4). Hötzel et al. (2009) observed that skin temperatures of growing pigs were 2.2% higher with the use of wood shavings or 3.9% with the use of rice husks in the pens compared with the concrete flooring, but these differences were not sufficient to influence performance and meat quality.

Another issue that can be raised is whether the material used as floor covering decreases or increases the stress of the animals. In this case, cortisol can be used as an indicator of stress (Beerda et al., 1999), especially in pigs, because its concentration can vary significantly during stressful conditions (Goymann et al., 2003; Gillespie et al., 2009). In the present study, no significant difference in salivary cortisol between the experimental groups was detected. However, there were variations during the experimental period within the studied groups. When compared with the initial values of salivary cortisol, at the end of the experiment, there was an increase of 170% in this hormone in the group of animals maintained on coffee husks. On the contrary, salivary cortisol levels showed a decrease of 30% in the control group. This result suggests that coffee husks may have some negative influence on animal welfare. Despite the increase of salivary cortisol levels, no animal showed stereotypical behavior, such as self-mutilation, excessive aggression, or poor libido. It is noteworthy that, although cortisol can be a useful stress marker, serum and, consequently, salivary concentration (Vining et al., 1983; Cook et al., 1996) of this hormone can vary among individuals that are held under the same conditions (Möstl and Palme, 2002); thus, this should not be the only way to assess animal welfare.

Regarding behavior, coffee husks did not affect the important aspects of behavioral characteristics of the animals. Pigs under natural conditions dedicate the greatest part of their active time to foraging and exploratory behaviors, such as nosing, grazing, rooting, and chewing (Petersen, 1994), but in intensive husbandry, pigs also appear to be highly motivated to exhibit explorative activities (Fraser and Broom, 1997). Hötzel et al. (2009) observed that wood shavings and rice husks increased play

activities and substrate manipulation in growing pigs and the animals spent more time lying or standing on the beds, decreasing peer-directed behaviors, indicating improved welfare. However, the behavioral characteristics of pigs may vary according to age. Bolhuis et al. (2005) observed that play behavior decreases with age, while the time spent chewing or rooting increases. In the present study, coffee husks reduced the number of times that the animals were standing, sitting, or rooting and increased the number of times they spent lying, demonstrating that the animals reduced their activities, preferring not to interact with the material, but to remain on it. This occurred because the control group remained on the concrete floor, which is physically less comfortable for the animals. The fact that the animals spent less time sitting indicates that the floor covering may have been favorable. Pigs housed on uncomfortable floors tend to remain in the “dog sitting position” (Mendes et al., 2004), as it was observed in the present study with boars kept on the concrete floor.

Studies have shown that pigs cool their bodies by lying on wet surfaces (Olsen et al., 2001). In the present study, removing the wet coffee husks was needed to avoid hoof problems in the animals. It is known that boars are animals more prone to hoof problems, not only because of the small surface area of the hooves relative to the total body weight (Webb, 1984), but also because during the ride to semen collection, 70% of the body weight of the animal is concentrated on the hind legs. In the present study, no animals showed hoof problems.

In general, stress causes alterations not only in animal behavior, but also in many other aspects, such as reproductive function. Thus, it has been described that stress causes pig reproductive losses linked to a decrease in the secretion of gonadotropic hormones caused by excess of corticosteroids (Tsuma et al., 1996). In the present study, coffee husks did not change the behavior of the animals in an obvious way. However, to meet the expected improvement in the environmental, economic, and ethical aspects of livestock production (Appleby, 2005), the choice of a substrate for floor covering should be based on a range of criteria, including cost, regional availability, practical aspects related to use, resulting environmental and agronomic qualities after composting of the bedding, and the performance and welfare of the animals.

Conclusions

Although coffee husks do not change the behavior of the animals in an expressive way, they should not be used as floor covering for boars.

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