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Hunger in pregnant sows: Effects of a fibrous diet and free access to straw

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ABSTRACT

Fibrous diets and the provision of straw have been suggested to reduce feeding motivation in pregnant sows. The present experiment investigated the separate and interactive effects of a fibrous diet and *ad libitum* access to straw on feeding motivation, oral behaviour and plasma levels of metabolites and hormones in pregnant sows. Ten groups of three pregnant sows were housed in pens with concrete floor where a limited amount of chopped straw (approx. 330 g/sow) was provided daily. In 5 of the 10 groups sows had free access to uncut straw in racks in addition to the chopped straw (*Ad libitum straw*), while the remaining 5 groups did not (*Limited straw*). The experimental period (week 2–9 of pregnancy) was divided into two 4-week periods and in a cross-over design sows within groups were fed a standard control diet (18% dietary fibre) during one period and a fibrous diet containing sugar beet pulp (35% dietary fibre) during the other period. Both diets were offered restrictively at 22 MJ net energy per day and throughout the experimental period sows were fed twice daily at 0800 and 1500 h. At the end of each 4-week period the undisturbed behaviour of the sows was recorded during two 24 h periods. Furthermore, the sows' feeding motivation was assessed during behavioural tests, and blood samples were draw *via* a jugular vein catheter, at 0700, 0900, 1200 and 1900 h in a balanced design. Feeding motivation was not affected by diet or straw. However, feeding motivation was highest 1 h before morning feeding indicated by a higher number of rewards earned during the entire test ($P < 0.01$) and during the first 5 min of the test ($P < 0.001$). In the period where sows were fed the fibrous diet they manipulated the floor less frequently ($P < 0.02$) and drank water less frequently ($P < 0.02$) than in the period they were fed the control diet. Sows with limited access to straw manipulated equipment less frequently during the period they were fed the fibre diet, while no effect of diet was seen among sows with *ad libitum* straw (diet × straw interaction $P < 0.001$). In conclusion, feeding motivation was not reduced by a fibrous diet or by *ad libitum* provision of straw. However, a fibrous diet did reduce frequency of drinking and floor directed explorative behaviour suggesting some alleviation of the adverse effects of hunger as supported by higher plasma levels of short-chain fatty acids and lower levels of the hunger hormone Ghrelin. *Ad libitum* straw did not reduce feeding motivation, but more lateral lying in sows with *ad libitum* straw suggests that the straw provided increased lying comfort.

1. Introduction

During pregnancy domestic sows' energy requirement for maintenance and foetal growth is much lower than their desired *ad libitum* intake and they are therefore fed a restricted diet corresponding to only approximately 50% of their *ad libitum* intake to avoid obesity and metabolic related health problems (Meunier-Salaün et al., 2001). As a consequence pregnant sows feel hungry during a large part of their pregnancy (D'Eath et al., 2009). Hunger in pregnant sows has been raised as an animal welfare issue and according to current EU legislation (Council Directive, 2001/88/EC) pregnant sows must have access to fibrous food, or straw, to satiate them and to satisfy the need to chew. However, it is still an open question whether these measures have any satiating effects.

Fibrous feeds can potentially influence feeding motivation in a number of ways. Firstly, substitution of fibre for starch results in a shift in the nature of absorbed energy from readily absorbed glycogenic energy to more slowly released short-chain fatty acids (SCFA) (Serena et al., 2009). Secondly, a direct consequence of the reduced diurnal variation in absorbed energy is lower fluctuation in insulin (Serena et al., 2009). Thirdly, fibrous diets results in more matter in the stomach and the remaining gut system which influence the

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sensory receptors that continuously monitor the composition of the gastrointestinal content (Zabielski, 2007; Serena et al., 2008; Furness et al., 2013). Therefore, sows consuming fibrous diets can be expected to be satiated for a longer period of time after feeding. This is regulated in the short term by the physical presence of digesta in the gut, which influences the stretch and chemoreceptors in the stomach and duodenum, and in the longer term by metabolic means resulting from the lower diurnal variation in energy uptake (Read et al., 1994). Several studies have investigated the effects of feeds high in dietary fibre in pregnant sows and gilts. In most studies feeding motivation has been measured in relation to feeding time. A lower feeding motivation both before and after feeding has been reported in pregnant gilts fed fibrous feeds (Robert et al., 1997, 2002). However, it appears to be a greater challenge to satiate pregnant sows because in studies including pregnant sows a lower feeding motivation was found only during the first hours after feeding, but not several hours later (Ramonet et al., 2000; Bergeron et al., 2000; Jensen et al., 2012).

Straw has been suggested to reduce hunger in pregnant sows through bulk and increased gut-fill (Tuyttens, 2005). However, mixing straw in the feed did not reduce hunger as measured by operant conditioning (Lawrence et al., 1988). It has also been suggested that straw may alleviate the adverse effects of hunger on sows' welfare by providing an outlet for foraging behaviour (Lawrence and Terlouw, 1993). For instance, abnormal behaviour in restrictively fed tethered sows was reduced by the provision of straw (Spoolder et al., 1995) and sows provided with straw explored this and directed less explorative behaviour towards pen fittings (Stewart et al., 2008).

The above studies have investigated the effects of dietary fibre and straw separately, but a recent study investigated the interactive effects of a fibrous feed and access to straw on the occurrence of abnormal behaviour (Stewart et al., 2011). They found that the combination of the two reduced sham chewing and bar biting, which are (abnormal behaviours) associated with hunger in pregnant sows (Appleby and Lawrence, 1987). This combined effect of dietary fibre and straw on sham chewing and bar biting may be due to an additive effect of the two factors on the level of hunger, however, no measure of feeding motivation was included in the study by Stewart et al. (2011). Alternatively, it may be that fibre reduces hunger to some extent, and that straw alleviates the adverse effects of a relatively low level of hunger by providing an outlet for appetitive foraging.

The aim of the present experiment was to investigate the combined effect of a fibrous feed and *ad libitum* access to straw on feeding motivation, oral behaviours, as well as plasma metabolites and hormones, related to hunger, in pregnant sows. It was hypothesised that dietary fibre reduces hunger in pregnant sows and that *ad libitum* access to straw had an additional effect.

2. Materials and methods

Animals were cared for and treated according to a protocol approved by the Danish Animal Experiments Inspectorate, Ministry of Justice, Copenhagen, Denmark.

2.1. Animals and housing

Thirty pregnant multiparous (second parity) sows entered the experiment in two blocks of 15 sows (50% Landrace, 50% Yorkshire). Within each block the sows were allocated to one of five group pens (three sows per pen), balanced for live weight and kinship. Each pen measured 2.5 m × 6.4 m and had concrete floor (two thirds solid and one third slatted). All pens were daily provided with 1 kg of chopped barley straw daily on the solid part of the floor. Water was freely available in the pen (one nipple per pen) and water was also available when sows were in the feeding stall (one nipple fitted in each trough). Artificial lights were on from 0600 to 2200 h.

2.2. Experimental treatments

Half of the pens were provided with *ad libitum* access to uncut barley straw in three straw racks placed on the pen partitions in the area of the pen with solid floor (*Ad libitum Straw*; three pens in block one and two pens in block two) while the other half of the pens did not have any straw except the 1 kg chopped barley straw that was provided to all pens on the solid floor (*Limited Straw*; two pens in block one and three pens in block two). Sows were offered two experimental diets in a cross-over design (sows in a pen were offered the same diet); one diet was fed during the last week before being moved to the pens plus during the first 28 days in the pens (period 1), while the other diet was fed for the last 28 days in the pens (period 2). Sows were allocated to diet order balanced for straw treatment. The two diets were made at the facility and were a control diet mainly based on wheat and barley providing 18% fibre and a high fibre diet formulated to provide 35% fibre by substituting grain by sugar beet pulp. Diets were similar to diets used in a previous experiment by our group and details on ingredients and chemical composition of these diets may be found in Jensen et al. (2012). Sows were fed restrictively a daily ration of 2.6 kg calculated to supply 35 MJ/d ME. Sows were fed twice daily (0800 h and 1500 h).

When they were moved to the experimental pens the sows' mean body weight (BW) was 225 (±22) kg, and at the end of the experiment their BW was 260 (±26) kg.

2.3. Feeders and training

Each pen had five feeding stalls with closing gates, three of which were fitted with feeders leaving an empty stall between each stall with a feeder to avoid interference of neighbouring sows during feeding. Solid sides separated stalls in adjacent pens. The feeders were built with a feed compartment with a portion container containing 1% of the daily restricted ration (26 g). This portion of feed was delivered in a trough following a predetermined number of operant responses on a circular transparent plastic panel. A correct response on this panel was signalled by a short flash of light and a buzzer sound. Self-written software controlled signals and feed delivery and collected the data for each session (number of responses, number of rewards, number of responses for the last reward, time since last press, time since last reward, and duration of session). The feeders and software are described in detail in Jensen et al. (2012).

The sows were moved to the pens at 0800 h on the first day of period 1. Prior to being moved the sows had not been fed since the previous day and immediately after being moved, all three sows in a pen were confined in the feeding stalls and simultaneously conditioned to press the panel with the snout for a food reward of the diet they were designated to receive in the first period. All sows learned to operate the panel within 30 min and throughout the experimental period sows always received their feed in their designated feeding stall by operating the panel.

Sows were conditioned to press the panel an increasing number of times for each successive food reward within each of two feedings (starting at 0800 and 1500 h) during the first 14 days of period 1 and this training was repeated during the first 14 days of period 2. In period 1 this was done to familiarise sows with the subsequent testing procedure and in period 2 this was done to get the sow back on consistent pressing-performance after the tests during the last 14 days of period 1. During this training the number of responses for each reward was first increased from 1 (Fixed