

Effects of dietary fibre and the provision of a foraging substrate on the welfare of sows in different grouping systems

Final report

Project 5402



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January, 2010

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1. Summary

There are no clear guidelines on how best to meet the EU legislative requirement (Council Directive 2001/88/EC) that pregnant sows and gilts should be provided with sufficient amounts of bulky or high fibre diets and high energy food to satisfy hunger and the motivation to chew. Therefore the aim of this project was to investigate the effect of increasing dietary fibre levels and providing access to a foraging substrate on the welfare of sows housed in dynamic and static groups. To achieve this a review paper was compiled and three experiments were conducted.

The aim of the review paper was to assess the effectiveness of increasing dietary fibre levels on the welfare of pregnant sows. Previous research found that increasing dietary fibre levels decrease activity levels and the performance of stereotypic behaviour, and increase resting behaviour. However, high fibre diets do not appear to reduce aggression between group-housed pregnant sows. The research clearly showed that the effectiveness of high fibre diets is influenced by the source of fibre, with soluble fibres being more effective in reducing stereotypic behaviours than insoluble fibres. However the optimum fibrous ingredient, or combination of ingredients, and the optimum dietary inclusion rate for these ingredients remains unclear.

The first experimental study assessed the effects of providing sows in large dynamic groups with access to straw in racks. Two treatments were applied: (1) Access to two racks containing chopped barley straw (offering an average of 0.3 kg straw/sow/day), (2) Control, with no straw racks. Treatments were applied to two separate dynamic groups each containing approximately 35 sows. Resident pen behaviour showed that sows with access to straw spent almost 10% of their time exploring the racks. Consequently, they spent less time exploring the floor and there were also reductions in general exploratory behaviour. Despite overall low levels of aggressive behaviour, there was more aggression in the straw treatment. Provision of straw had no effect on sham chewing behaviour. These findings suggest that welfare benefits associated with providing sows in large dynamic groups with access to straw racks are limited. Nevertheless providing longer or more straw racks could enable more sows to access them which could result in a larger positive impact on sow welfare.

The second experimental study assessed the effect of increasing fibre levels in the concentrate ration on the welfare of sows housed in large dynamic groups. Two treatments were applied to two separate dynamic groups each containing about 33 sows in a cross-over design. Treatments were as follows: (1) High Fibre Diet (~15% CF (Crude fibre)), and (2) Control diet (~5% CF). Increasing fibre levels resulted in sows spending more time lying, and promoted the use of kennel areas by sows newly introduced to the group and reduced the performance of stereotypic behaviour. Overall levels of aggression did not differ between treatments, however sows in the control treatment performed more bouts of head thrusting and biting than sows on the high fibre diet. There were no treatment effects on plasma cortisol or haptoglobin levels. In conclusion, provision of a high fibre diet had a positive effect on the welfare of dry sows housed in a large dynamic group.

The third experimental paper assessed the effect of increasing dietary fibre levels and providing straw in racks on the welfare of sows in small static groups. In a 2x2 factorial design experiment, sows were offered one of two diets: (1) High fibre diet with 9% crude fibre, or (2) Control diet with 4.5% CF, and one of two levels of access to a foraging substrate: (1) access to straw in racks or (2) no straw. The study was replicated eight times and treatment periods lasted 4 weeks. Post-mixing levels of aggression were very low but access to straw in racks resulted in fewer bouts of head-thrusting. Sows offered the control diet spent more time inactive than sows on the high fibre diet, however sows offered the high fibre diet spent more time lying with eyes closed and therefore appeared to rest more. The provision of the high fibre diet with access to straw resulted in less sham

chewing and bar biting compared to other treatments. These results show that provision of a diet containing 9% crude fibre led to some welfare benefits for group-housed sows, but that it was necessary to combine it with access to straw to reduce stereotypic behaviour.

In conclusion, the provision of high fibre diets led to improved welfare of group-housed sows in small static and large dynamic groups. These effects were more pronounced when rations contained 15% rather than 9% crude fibre, however this may reflect to some extent the different management systems in which they were assessed. Provision of access to straw racks led to limited welfare benefits in large dynamic groups, but appeared to have additive welfare benefits for sows in small static groups when combined with high fibre rations.

2. Introduction

Under EU legislation housing sows individually in gestation stalls will be prohibited except for the first four weeks post-service from 2013. This means that thereafter sows will typically be housed in one of two grouping systems, i.e. in large dynamic groups or small static groups, or using a combination of both (Barnett *et al.*, 2001; Durrell, 2002). In general, such systems are thought to improve sow welfare in comparison to individual confinement systems (Barnett *et al.*, 2001; Kirkden and Pajor, 2006), however there are still welfare problems associated with these systems. For example, the environments in which sows are group housed are often barren and un-stimulating (Durrell, 2002), as a result the sows are unable to express natural exploratory behaviours (Day *et al.*, 2008). In addition, the pigs are often subjected to abrupt mixing with unfamiliar animals (Turner *et al.*, 2006) and this can lead to intense aggression (Broom *et al.*, 1995). However, possibly the most significant welfare problems arise from the fact that diets of pregnant sow are typically restricted to approximately 60% of their *ad libitum* intake (Lawrence *et al.*, 1988). In addition, these diets are often offered in one short meal per day (Brouns *et al.*, 1994b). As a result, the sows have an unfulfilled feeding motivation, and this is linked to poor welfare (Ramonet *et al.*, 2000b) and increased aggression (Jensen *et al.*, 2000). In addition, the sows are deprived of an opportunity to perform natural foraging behaviours (Meunier-Salaün, *et al.*, 2001). Both hunger and lack of ability to perform foraging behaviours contribute to the high levels of stereotypic behaviours, such as sham chewing, shown by sows in group housing systems (Durrell *et al.*, 1997).

Steps have been taken to improve the welfare of grouped housed pregnant sows, particularly in the form of amendments to legislative requirements. European Union pig welfare legislation (Council Directive 2001/88/EC) states that pregnant sows must be provided with bulky or high fibre diets, and that pigs of all ages must be provided with appropriate environmental enrichment. The provision of high fibre or bulky diets is thought to alleviate the feelings of sustained hunger and unfulfilled foraging motivation (Meunier-Salaün, *et al.*, 2001), and the provision of suitable environmental enrichment allows pigs the opportunity to perform species-specific exploratory behaviour (Day *et al.*, 2008). However the legislative requirements are open to interpretation and very few guidelines are available on how they should be implemented at farm level in a manner that is both practical and effective.

Previous research has focussed on increasing dietary fibre levels in concentrate rations of pregnant sows as one method of meeting part of these legislative requirements. The general consensus from this research is that high fibre diets can improve welfare by increasing levels of satiety in pregnant sows (e.g. Brouns *et al.*, 1994a; Ramonet *et al.*, 2000b). However the majority of this research investigated the effects of high fibre diets on sows housed in gestation stalls (e.g. Vestergaard and Danielsen, 1998; Robert *et al.*, 2002; Holt *et al.*, 2006) or in static groups (e.g. van der Peet-Schwering *et al.*, 2003a; Zonderland *et al.*, 2004). Therefore the literature on the impact of high fibre diets on the welfare of sows in large dynamic group systems is limited. There are also several factors which influence the effectiveness of high fibre diets in improving sow welfare, for example source of fibre (Le Goff and Noblet, 2001; Jørgensen *et al.*, 2007; Serena *et al.*, 2007) and fibre inclusion level (Brouns *et al.*, 1994a; Matt *et al.*, 1994; Bergeron *et al.*, 2000). However there seems to be little consensus in the literature on the optimum fibre level to include in pregnant sow rations. In addition, much of the research on high fibre diets focussed on the use of sugar beet pulp as a fibre source (e.g. Brouns *et al.* 1994a; Vestergaard and Danielsen, 1998; Danielsen & Vestergaard, 2001; Zonderland *et al.*, 2004; De Leeuw *et al.*, 2005). However, the long ingestion time associated with this ingredient (Brouns *et al.*, 1994a) may not suit some feeding systems therefore there is a need to investigate the effectiveness of other fibre sources.

The provision of foraging substrates is another potential method of meeting legislative requirements to provide sows with bulky or high fibre diets, and also to provide them with environmental enrichment. This is commonly achieved by providing straw bedding to group housed sows

(Whittaker *et al.*, 1999; Spoolder *et al.*, 1995; 1996; Tuyttens, 2005). This practice appears to have a number of benefits in terms of increasing the performance of foraging behaviour (Whittaker *et al.*, 1999), and improving comfort and satiety levels (Tuyttens, 2005). Despite the potential benefits of straw bedding for group housed sows this is not practical in partially slatted or fully slatted housing systems. This is due to straw falling in to the slurry tank and causing blockages as well as increasing the volume.

3. Objectives

The overall aim of this thesis was to investigate the effect of increasing dietary fibre levels (primarily through the use of soya hulls) and the provision of straw in racks on the welfare of sows housed in different grouping systems. This was achieved by:

1. Conducting a literature review investigating the effects of the inclusion of fibrous ingredients in pregnant sow diets on sow welfare
2. Assessing the effects of providing access to straw in racks on the welfare of sows in a large dynamic group
3. Assessing the effect of increasing dietary fibre levels on the welfare of sows in a large dynamic group
4. Investigating the effects of increasing dietary fibre levels and/or providing access to straw in racks on the welfare of sows housed in small static groups

4. Experiments

4.1 Influence of access to straw provided in racks on the welfare of sows in large dynamic groups

Introduction

Group housed sows are regularly exposed to abrupt mixing periods with unfamiliar animals. Furthermore, the housing environment often limits the animal's ability to utilise and display appropriate submissive behaviours required to avoid aggressive attacks (Turner, *et al.*, 2006). The particular welfare concern with dynamic compared to static housing systems is that the dominance hierarchy is regularly disrupted as sows are removed for farrowing and newly served sows are re-introduced to the group. For instance newly introduced sows can be subjected to high levels of aggression from resident sows (O'Connell *et al.*, 2003). In growing pigs the presence of straw decreases levels of aggression at mixing (Beattie *et al.*, 1995). It also facilitates the expression of foraging behaviour in feed restricted sows. The aim of this study was to assess the effect of providing access to straw in racks on the welfare of sows in a large dynamic group.

Materials and methods

One hundred and twenty-two Large White x Landrace sows were allocated to one of two treatments over seven replicates. Treatments were as follows: (1) Access to racks containing chopped barley straw (offering an average of 0.2kg straw/sow/day), (2) Control, with no straw racks. Treatments were applied to two separate dynamic groups each containing 35 (± 3) sows. Approximately 9 sows were replaced in each of these groups at 3-week intervals (each replacement constituting a replicate of the study). Treatments were swapped between the two dynamic groups after three replicates, with a 3-week adjustment period before observations recommenced. Both dynamic groups were housed in identical split-yard systems (18.2 x 7.8 m) with slatted exercise and drinking areas and solid-floored kennel areas in both the pre- and post-feeding yards. The pre-feeding yard was separated from the post-feeding yard by an electronic feed station, which supplied 2.2 kg concentrates/sow/day. In treatment 1, straw was provided in a rack (0.8m high x 1.2m wide, with 5.3cm² mesh) which was located in the slatted exercise area of the pre- and post-feeding yards. The rack was attached to railings and was suspended 0.3m above a collecting mat (0.6 x 1.5m). Resident pen behaviour was observed directly from three newly-introduced and three resident sows during a 5 min period on three afternoons in the first week, and two afternoons in the second week, after sows were replaced in the group. A full ethogram of social, exploratory and aggressive behaviours was used. Each sow was also scanned instantaneously on three afternoons during week 1, and on two afternoons during week 2, to determine their location and whether or not they were performing sham chewing behaviour. Aggression-related injuries were scored on all newly-introduced sows at 1 week post mixing. Resident pen behaviour and injury scores were analysed by ANOVA, and sham chew scans were analysed by Binomial Regression using Genstat 5.

Results

General activities

The influence of providing access to straw in racks on the location, posture and activity of the newly introduced sows is shown in Table 1. In the control treatment sows spent more time standing in the kennel areas ($P < 0.05$), whereas in the straw treatment sows spent more time lying in the kennel areas ($P < 0.05$). There were no differences in sow posture overall ($P > 0.05$) or sow posture within slatted areas ($P > 0.05$). However, sows in the control treatment spent more time engaged in general exploration ($P < 0.019$), and more time exploring the kennel ($P < 0.019$) and slatted areas ($P < 0.001$) compared to sows in the straw treatment. None of the other activities differed between treatments ($P > 0.05$).

Table 1 Influence of access to straw on the average proportion of time spent in different behaviours by newly-introduced sows during the first 3 weeks in a large dynamic group

Parameter	Control	Straw	S.E.M.	P
Overall				
Kennel areas	0.729	0.706	0.0207	NS
Slatted areas	0.267	0.289	0.0198	NS
Sitting	0.011	0.013	0.0020	NS
Standing	0.406	0.379	0.0214	NS
Lying	0.583	0.608	0.0220	NS
Exploration	0.371	0.287	0.0211	0.019
Within kennel areas				
Sitting	0.015	0.015	0.0035	0.958
Standing	0.217	0.148	0.0172	0.017
Lying	0.771	0.834	0.0192	0.029
Exploration	0.217	0.148	0.0173	0.019
Within slatted areas				
Sitting	0.002	0.009	0.0037	0.216
Standing	0.932	0.939	0.0200	0.815
Lying	0.065	0.052	0.0186	0.614
Exploration	0.802	0.612	0.0248	<0.001

Sham chewing

A higher proportion of sows performed sham chewing behaviour in the post- compared to the pre-feeding yard in both treatments (Straw: pre-feeding yard 0.09, post-feeding yard 0.33; Control: pre-feeding yard 0.04, post-feeding yard 0.36, $P < 0.01$). However, levels of sham chewing behaviour did not differ significantly between treatments (Straw 0.20, Control 0.20, $P > 0.05$).

Use of rack

On average over a 24-hour period, 2% of sows were observed at each rack, with a higher percentage being observed at the post- rather than at the pre-feeding rack (prefeeding yard 1.6%, post-feeding yard 2.5%, s.e.m. 0.178% $P < 0.001$). Peak rack usage was between 0800 and 1200 hours, when on average 6% of sows were observed at each rack. Twenty seven per cent of sows that were observed at the racks were newly-introduced. This was significantly higher in the pre- rather than in the post-feeding yard (prefeeding yard 32.5%, postfeeding yard 21.1%, $P < 0.05$).

Aggression at the rack

Resident sows at the rack performed more aggressive behaviours (resident sow: 0.003, newly introduced sow: 0.001, $P < 0.001$) and received more aggression (resident sow: 0.003, newly introduced sow: 0.001, $P < 0.001$) than newly introduced sows. More aggression was performed in the prefeeding yard (prefeeding yard: 0.002, post-feeding yard 0.001, $P < 0.05$).

Injury scores

No significant difference between treatments was shown in total injury score (Straw: 6.50, Control 4.88, s.e.m. 1.257, $P > 0.05$).

Post mixing aggression

Although overall levels of aggression were low, the proportion of sows which performed aggressive behaviour after mixing was greater in the straw compared to the control treatment (Straw: 0.02, Control: 0.01, $P < 0.001$).

Focal observations

Observations of resident pen behaviour showed that sows with access to straw spent approximately 9% of their time exploring the racks/consuming straw. Sows in the straw treatment spent a significantly lower percentage of time exploring the floor of the pen (Straw: 4.82, Control: 12.41, s.e.m. 1.756, $P < 0.05$). No significant treatment effects were shown in overall exploratory behaviour (Straw: 21.0, Control: 19.6, s.e.m. 1.75, $P > 0.05$). There were no other significant differences between treatments in focal animal behaviour.

Discussion

Provision of straw racks resulted in sows spending less time involved in exploratory behaviour directed towards the fixtures and fittings and redirecting their exploratory behaviour towards the racks. This indicates that the sows were attracted to the straw in the racks. However, there was no effect of straw on the overall time spent in exploratory behaviours. Nevertheless the fact that the sows redirected their attention to the straw racks suggests that the straw did facilitate the expression of foraging behaviours.

Sows performed more sham chewing in the post-feeding yard. This agrees with the suggestion that sham chewing is stimulated by the ingestion of feed (Spoolder *et al.*, 1995). A reduction in sham chewing is thought to be an indication of a reduced motivation to forage and an improvement in welfare (Lawrence and Terlouw, 1993; Brouns *et al.*, 1994). This may occur when sows are able to increase the performance of foraging behaviour (Spoolder *et al.*, 1997). However, the performance of foraging behaviour did not result in a reduction in sham chewing in the current study. Sham chewing can also be reduced owing to greater satiation due to the absorption of additional nutrients, or increased 'gut-fill' linked with consumption of fibrous material (Lawrence and Terlouw, 1993; Whittekar *et al.*, 1999). However, the small amount of straw available to the sows combined with relatively low rack usage means that the amount of straw ingested was likely to be insufficient to achieve this effect.

The presence of straw encouraged more resting and lying in the kennel areas whereas in the control treatment sows were more involved in exploratory behaviours in both the slatted and kennel areas. The presence of the straw racks may have increased animal traffic in the slatted areas making it more difficult for sows to rest in this area. This had the effect of encouraging the sows to use the kennel areas for resting and seemed to improve the differentiation by sows between areas for resting and areas for performing exploratory behaviour. Increasing the use of solid floored kennel areas for resting may have welfare benefits for the sows. For example reduced exploratory behaviour in these areas could result in reduced disturbance to resting animals (Durrell, 2000). The kennel areas also have the benefit of being warmer and more comfortable than the slatted areas.

The straw racks resulted in higher levels of aggression at mixing in the current study. There was no difference in injury scores between treatments which may be due to the fact that overall levels of aggression at mixing were low. This has also been noted in previous studies with the same housing system (O'Connell *et al.*, 2003). The increased aggression in the straw treatment suggests that there was competition between sows for access to the rack. Most of the aggression that occurred at the rack was between resident sows. It is likely that this aggression was due to the establishment of dominance relationships (Spoolder *et al.*, 1997) rather than to feed related aggression (Brouns and Edwards, 1994; Zonderland *et al.*, 2004) particularly considering that peak usage of the rack occurred in the post-feeding yard. Our results are in accordance with Durrell (2000) who found that the provision of sawdust on solid flooring increased aggression. However the effect on aggression appears to be dependant on the type of enrichment as spent mushroom compost suspended racks resulted in a decrease in aggression (Durrell *et al.*, 1997). Previous studies have shown that straw as an enrichment tool either had no affect or reduced levels of aggression (Beattie *et al.*, 1995). Jensen *et al.* (2000) found that groups of sows provided with large amounts of straw showed reduced

aggression compared to groups of sows without straw. Obviously the attractiveness of straw to sows means that it can induce aggression (Krause *et al.*, 1997) especially if access to it or the amount provided is restricted (Jensen *et al.*, 2000).

Peak rack usage coincided with peak feeding and activity times with the majority of sows using the post feeding rack. This is in agreement with the suggestion that access to a foraging substrate in the post feeding yard is important because sows appear to be highly motivated to perform foraging behaviours after eating (Jensen, 1988; Spooler *et al.*, 1995; Whittaker *et al.*, 1998).

Newly introduced sows often have difficulty gaining access to prioritised resources in dynamic groups (O'Connell *et al.*, 2003). In the current study the proportion of newly introduced sows at the rack at any one time was relatively large suggesting that they did not have difficulty gaining access to the straw. However, the newly introduced sows showed greater usage of the rack in the pre-feeding yard where it was less in demand than in the post-feeding yard. The greater interest in the rack shown by the newly introduced sows in the pre-feeding yard was likely the cause of the higher number of aggressive interactions recorded there.

Conclusions

The fact that sows with access to straw racks diverted almost half of their exploratory behaviour towards the straw in the racks suggests that they offered some welfare benefits. The presence of the racks also improved the spatial behaviour of the sows. Nevertheless, it is likely that competition for access to the straw racks provoked aggression. It is possible that the sows did not ingest enough straw to reduce feeding motivation and hence impact on sham chewing behaviour. The provision of more straw and facilitating access to straw by all sows via longer or more numerous racks could help overcome these problems.

4.2 The effect of feeding a high fibre diet on the welfare of sows housed in large dynamic groups

Introduction

Pregnant sows are often fed a restricted diet in order to optimise reproduction performance (Ramonet *et al.*, 2000a), but which often results in sows remaining hungry. Sows are typically restricted to 60% of their ad libitum intake (Ramonet *et al.*, 2000a). Hunger in pregnant sows is thought to lead to increased aggression (Jensen, *et al.*, 2000), increased physical activity (De Leeuw *et al.*, 2005) and the development of stereotypies (Lawrence and Terlouw, 1993).

Research has shown that increasing the dietary fibre content of pregnant sow diets through use of sugar beet pulp is highly effective in improving sow welfare (Brouns *et al.*, 1994a; Ramonet *et al.*, 2000b). This is because sugar beet pulp contains high levels of soluble fibre which are readily digested compared to fibre provided from more 'insoluble' sources (Serena *et al.*, 2007). However, sugar beet pulp can also increase feeding time relative to control diets (Brouns *et al.*, 1994a). This may not suit some commercially-operated systems where large groups of sows are fed sequentially, and where all sows must complete a feeding cycle within a specified time frame. Therefore, it is important to assess the effectiveness of other fibre sources such as soya hulls, used in combination with sugar beet pulp, in improving the welfare of pregnant sows in large group systems.

The aim of this study was to assess the effect of providing increased levels of dietary fibre (through use of soya hulls) on the welfare of sows in a large dynamic group housed in a split yard system, which includes separate pre and post feeding yards. Welfare was assessed using a multi-disciplinary approach which included recording behaviour, injury levels and physiological parameters.

Materials and methods

One hundred and twelve Large White x Landrace sows were allocated to one of two treatments over six replicates. Treatments were as follows: (1) 2.85kg/sow/day High Fibre Diet (~15% CF), (2) 2.2 kg/sow/day of Control diet (~5% CF). Treatments were applied to two separate dynamic groups each containing 33 (± 3) sows. Approximately 9 sows were replaced in each of these groups at 3-week intervals (each replacement constituting a replicate of the study). Both dynamic groups were housed in identical split-yard systems (18.2 x 7.8 m) with slatted exercise and drinking areas and solid-floored kennel areas in both the pre- and post-feeding yards. The pre-feeding yard was separated from the post-feeding yard by an electronic feed station. The behaviour of three newly-introduced and three resident sows was recorded twice daily on two non-consecutive days for the first 3wks after sows were replaced in the group. A full ethogram of social, exploratory and aggressive behaviours was used. Data on sham chewing and the spatial behaviour of all sows in the groups were collected by instantaneous scan sampling. General activities of newly introduced sows were observed at hourly intervals once a week from video recordings. Aggression-related injuries on the newly-introduced sows were scored from 0 to 3 according to severity 1 week post mixing. General behaviour and injury scores were analysed by ANOVA. Data on sham chewing were analysed by Binomial Regression using Genstat 5.

Results

Selected behavioural results are presented in Table 1. Resident pen behaviours shows that sows on the high fibre diet spent more time resting ($P < 0.01$) while sows on the control diet spent more time exploring and sham chewing ($p < 0.001$). Aggression occurred at a very low frequency and overall levels did not differ between treatments. This explains the lack of a difference in injury scores between treatments ($P > 0.05$, data not shown). Nevertheless, sows in the control treatment performed more head thrusting ($p < 0.01$) and biting ($p < 0.05$) than sows on the high fibre diet.

Table 1 The effect of a high fibre diet on the duration of activities and frequency of aggressive behaviours

Parameter	Control	High fibre	SEM	Significance
<i>Activity (% of time)</i>				
Inactive (eyes open)	16.67	22.79	2.273	ns
Sleeping (eyes closed)	28.00	43.80	3.25	**
Sham chewing	28.76	7.24	1.546	***
<i>Aggressive Behaviours (min⁻¹)</i>				
Aggressive biting	0.02	0.01	0.002	*
Headthrusting	0.02	0.00	0.001	**
Overall aggression	0.005	0.003	0.0007	ns

Sows on the high fibre diet spent proportionally less time sham chewing (High Fibre: 7.2%, Control: 28.8%, s.e.m. 1.55%, $F_{(1,10)}=96.76$, $P<0.001$). Observations of the entire group showed that a smaller proportion of sows performed sham chewing in the high fibre treatment compared to the control treatment (High Fibre: 0.178 s.e.m. 0.015, Control: 0.313 s.e.m. 0.014, $P<0.001$). The post-feeding sham chew observations of newly introduced sows showed that these sows also performed proportionally more sham chewing in the control treatment compared to the high fibre treatment (High Fibre: 0.249 s.e.m. 0.012, Control: 0.378 s.e.m. 0.013, $P<0.001$).

The influence of providing a high fibre diet on the location, posture and activity of newly introduced sows to the dynamic group is shown in Table 2. Newly introduced sows in the high fibre treatment spent proportionally more time in the kennel areas and less time in slatted areas compared to newly introduced sows in the control treatment. Sows in the high fibre treatment spent less time standing and more time lying than sows in the control treatment. Treatment also had an effect on exploration, with sows in the high fibre treatment spending proportionally less time exploring overall, and exploring in kennel areas compared to sows in the control treatment. None of the other activities differed between treatments.

Table 2 Influence of providing a high fibre diet on the average proportion of time spent in different behaviours by newly-introduced sows during the first 3 weeks in a large dynamic group

Parameter	High Fibre	Control	S.E.M.	$F_{(1,10)}$	P
Overall					
Kennel areas	0.893	0.788	0.0328	5.10	<0.05
Slatted areas	0.106	0.210	0.0326	5.07	<0.05
Sitting	0.009	0.018	0.0022	7.68	<0.05
Standing	0.226	0.293	0.0212	4.94	0.05
Lying	0.765	0.689	0.0216	6.12	<0.05
Exploration	0.217	0.296	0.0214	6.79	<0.05
Within kennel areas					
Sitting	0.028	0.018	0.0023	6.63	<0.05
Standing	0.136	0.178	0.0132	5.06	<0.05
Lying	0.854	0.803	0.0147	5.92	<0.05
Exploration	0.146	0.195	0.0145	5.76	<0.05
Within slatted areas					
Sitting	0.003	0.021	0.0072	3.09	NS
Standing	0.970	0.845	0.0367	5.77	<0.05

Lying	0.027	0.134	0.0321	5.54	<0.05
Exploration	0.787	0.784	0.0414	0.00	NS

Discussion

The high fibre diet resulted in sows spending more time resting, whereas sows in the control treatment spent more time exploring. This is in agreement with a previous study by Ramonet *et al.* (1999), which found that feeding high levels of fibre to sows reduced standing activity by 25% compared to low fibre diets. Previous studies also found that increasing the level of dietary fibre reduced exploration (Robert *et al.*, 1993; Brouns *et al.*, 1994a; Zonderland *et al.*, 2004). Exploratory behaviour in pigs is thought to be an expression of the need to forage or feed (Lawrence and Terlouw, 1993). Hence a reduction in foraging behaviour is likely to reflect improved welfare for sows as it may be an indication of increased satiety (Ramonet *et al.* 1999). Increased lying behaviour is also thought to reflect increased satiety in sows, and thus improved welfare (Ramonet *et al.*, 1999).

Newly introduced sows in the high fibre treatment spent proportionally more time in the kennel areas compared to newly introduced sows in the control treatment. This increased time in the kennel areas may have reflected an increased motivation to rest in the high fibre treatment. The kennel areas have the advantage of being warmer and dryer compared to the slatted areas, and therefore may be viewed as a prioritised resource. Previous research suggests that sows newly introduced to a large dynamic group often have difficulty gaining access to prioritised resources (O'Connell *et al.*, 2003). It is possible that the increased use of the kennel areas shown in the high fibre treatment in the present study may reflect an improved ability to gain access to resources and consequently improved social integration (Spooler, 1998). In the current study there was also a reduction of exploratory behaviour within kennel areas, and this may have the additional benefit of reducing disturbance to resting animals (Durrell, 2000).

In general, aggression occurred at a very low frequency and overall levels during the immediate post mixing period did not differ between treatments. This explains the lack of a difference in injury scores between treatments. Low levels of post-mixing aggression were previously found in the same housing system (O'Connell *et al.*, 2003), indicating that this particular system is beneficial in reducing aggression within large groups of sows. However, focal observations showed that sows in the high fibre treatment, performed fewer instances of head thrusting and biting than sows on the control diet. This suggests that high fibre diets may ameliorate some forms of aggression (i.e. those which do not arise directly from mixing) in group housed sows. This supports suggestions by Meunier-Salaün *et al.* (2001) who reported that high fibre diets help to reduce aggression in group housed sows.

In the present study, sows on the high fibre diet showed a significant reduction in sham chewing behaviour. This provides further evidence that the high fibre diet promoted satiety, which may have been due to the consumption of fibrous material which is associated with increased 'gut fill' (Lawrence and Terlouw, 1993; Whittaker *et al.*, 1999). In addition, satiety due to increased dietary fibre levels is associated with prolonged energy supply and continuous release of nutrients produced by increased hind gut fermentation (Ramonet *et al.*, 2000a). Brouns *et al.* (1994b) suggested that fibre fermentation and absorption of increased levels of acetate associated with high fibre diets alters glucose metabolism maintaining satiety for longer, thus reducing stereotypic behaviour. This is in agreement with the current study which reported a significant reduction in the performance of stereotypic behaviours when high fibre diets were offered. In this study the fibrous ingredients included sugar beet pulp and soyabean hulls which provide relatively high levels of soluble fibre (Johnston *et al.*, 2003).

Conclusions

Provision of a high fibre diet had a positive effect on the welfare of group housed dry sows. Sows fed the high fibre diet spent more time resting and using the kennel areas, and less time performing

stereotypic behaviours and certain aggressive behaviours. These improvements were not reflected in the physiological parameters, which did not differ between treatments.

4.3 The effect of increasing dietary fibre and the provision of straw racks on the welfare of sows housed in small static groups

Introduction

European Union pig welfare legislation requires that pregnant sows be provided with bulky or high fibre diets (Council Directive, 2001/88/EC). This legislative requirement can be met by increasing the fibre content of the concentrate ration and/or through providing sows with access to a foraging substrate. There has been a significant amount of research on the effect of increasing the fibre content of the concentrate ration using sugar beet pulp in *ad libitum* dry feeding systems (Brouns *et al.*, 1995). In addition wet feeding pigs is becoming increasingly popular due to the fact that it is a cost effective method of feeding as it uses low dry matter products (Scott *et al.*, 2007). There are a number of health and welfare benefits believed to be associated with liquid feeding systems. For example, satiety levels in sows may be further improved by wet feeding which can result in improved gut fill (Bergeron *et al.*, 2002; Scott *et al.*, 2007). However, there is limited information available on the impact of wet feeding on pig health and welfare (Scott *et al.*, 2007).

The effectiveness of providing sows with access to a foraging substrate such as straw may also differ depending on how it is offered. Research shows that providing group-housed sows with access to straw as a bedding substrate improves welfare levels (Tuytens *et al.*, 2005). However, providing straw as bedding is not possible in slatted systems or in areas where straw is in short supply. Providing sows with access to straw in racks led to limited welfare benefits for sows housed in large dynamic groups, however accessibility appeared to be an issue (experiment 4.1). It is possible that the effectiveness of providing sows with access to straw in racks is improved when sows are housed in small static groups.

The aim of this study was to assess the relative benefits of increasing dietary fibre levels (through use of soya hulls), or of providing access to straw in racks, for sows housed in small static groups and fed using a wet feeding system. Whether or not there were any additive benefits associated with providing both regimes was also assessed. Welfare was assessed using behavioural observations and injury scores.

Materials and methods

In a 2 x 2 factorial design experiment, pregnant sows (n=128) were offered one of two diets: (1) High (H) fibre diet with 10% acid detergent fibre (ADF), or (2) Control (C) diet with 5% ADF and (1) access to straw (S) in racks or (2) no (N) straw. Groups of four sows were formed at the start of the 4-week treatment period. Sows were housed in pens with voluntary cubicles and a slatted exercise area and were fed twice a day. Back fat levels were assessed before mixing and 4 weeks later. Aggressive interactions were assessed immediately post mixing. Injury scores were recorded one week post mixing. General activity scans were made one day per week at hourly intervals over a 12-hour period. Focal observations and sham chew scans were made on two non-consecutive days each week. Straw usage was also recorded.

Results

Aggressive behaviour post-mixing

There was no effect of treatment on the proportion of scans showing the performance of aggression post mixing (Fibre: 1.00, Control: 0.94, $P>0.05$; Straw: 0.94, No Straw: 1.00, $P>0.05$).

Focal observations

The high fibre diet caused a reduction in the proportion of time that sows spent biting the bars (Control: 0.365, High Fibre: 0.080, s.e.m. 0.0699, $P<0.05$). Sows on the high fibre diet also performed fewer bouts of chewing on their pen mates (Control: 0.042, High fibre: 0.010, s.e.m. 0.0083, $P<0.05$) and performed more bouts of exploring the floor (Control: 0.188, High Fibre: 0.262,

s.e.m. 0.0214, $P < 0.05$) and exploring the pen fixtures (Control: 0.182, High Fibre: 0.359, s.e.m. 0.0387, $P < 0.05$). The presence of straw in racks reduced the occurrence of head thrusting (No Straw: 0.005, Straw: 0.001, s.e.m. 0.0010, $P < 0.05$). The provision of the high fibre diet and the presence of straw racks also caused a reduction in the proportion of time that sows spent sham chewing (Control: No straw 20.10^a, Straw 8.76^b, High Fibre: No straw 24.18^a, Straw 7.33^b, s.e.m. 2.695, $P < 0.05$). There was an increase in the performance of exploratory behaviour when sows were provided with both the high fibre diet and straw in racks (Control: No straw 30.65^a, Straw 43.97^b, High Fibre: No straw 39.09^b, Straw 51.74^b, s.e.m. 5.294, $P < 0.05$). There were no other significant differences between treatments in focal animal behaviour.

Sham chewing and bar biting

The provision of the high fibre diet and straw in racks significantly reduced the proportion of sows performing sham chewing (Control: No straw 0.294^a, Straw 0.1488^b, High Fibre: No straw 0.290^a, Straw 0.088^c, $P < 0.001$). There was also a reduction in the proportion of animals that were biting the bars when the high fibre diet and straw in racks were provided (Control: No straw 0.003^a, Straw 0.003^a, High Fibre: No straw 0.003^a, Straw 0.001^b, $P < 0.05$).

General activity, posture and spatial time budgets

The influence of providing a high fibre diet and straw in racks on the activity budgets of the sows is shown in Table 1. Sows on the control diet spent proportionally more time inactive in the slatted exercise area (Control: 0.238, High Fibre: 0.177, s.e.m. 0.0314, $P < 0.05$) whereas sows on the high fibre diet spent proportionally more time lying with their eyes closed in the voluntary cubicles (Control: 0.414, High Fibre: 0.546, s.e.m. 0.0316, $P < 0.05$).

Table 1 The influence of providing a high fibre diet and straw in racks on the activity of sows in static groups

Parameter	Control		Fibre		SEM	P-value
Active	0.352		0.367		0.0183	NS
Inactive	0.240		0.117		0.0237	<0.001
Lying eyes closed	0.405		0.516		0.0670	<0.05
Other	0.001		0.001		0.0007	NS
	No straw		Straw		SEM	P-value
Active	0.376		0.345		0.0183	NS
Inactive	0.179		0.174		0.0237	NS
Lying eyes closed	0.405		0.516		0.0231	NS
Other	0.001		0.000		0.0007	NS
	Control		Fibre		SEM	P-value
	No straw	Straw	No Straw	Straw		
Active	0.358	0.351	0.393	0.340	0.0259	NS
Inactive	0.240	0.240	0.117	0.117	0.0335	NS
Lying eyes closed	0.401	0.409	0.488	0.544	0.0326	NS
Other	0.000	0.000	0.002	0.000	0.0010	NS

Injury scores

There was no effect of treatment on injury scores (Control: No straw 0.5.35, Straw 5.22, High Fibre: No straw 6.56, Straw 5.47, s.e.m. 0.787, $P > 0.05$).

Back fat and weights

There were no treatment interactions on weight change throughout the treatment period (Control: No straw 8.60, Straw 9.25, High Fibre: No straw 18.12, Straw 19.02, s.e.m. 1.296, $P > 0.05$). Although

sows on the high fibre greater showed greater weight gain (Control: 8.93, High Fibre: 18.57, s.e.m. 0.916, $P < 0.001$). There were also no significant differences in back fat levels when the treatments were completed (Control: No straw 14.81, Straw 13.47, High Fibre: No straw 13.05, Straw 13.45, s.e.m. 0.654, $P > 0.05$).

Straw usage

On average the sows were offered 0.32 kg straw/sow/day of chopped barley straw and approximately 0.27 kg straw/sow/day was used. The dietary treatments had no effect on the total weekly amount of straw used per treatment (Control: 17.0 kg, High Fibre: 17.1 kg, s.e.m. 4.91 kg, $P > 0.05$).

Discussion

In contrast to previous studies (Robert *et al.*, 1993; Ramonet *et al.*, 1999) the high fibre diet alone did not significantly reduce stereotyping in the loose housed sows. This may have been because the level of fibre used in the diet was lower compared to previous studies (Ramonet *et al.*, 1999; Bergeron *et al.*, 2000). This combined with the fact that the sows were fed a wet diet twice a day which reduces the amount of food in each meal delivery in comparison to once a day feeding (Holt *et al.*, 2006) might have reduced the gut fill effect of the diet. A combination of the high fibre diet and straw in racks was required to significantly reduce stereotyping. This indicates that the straw acted as a supplementary fibre source that improved gut fill to the point that stereotyping was reduced. It is likely that the straw also helped to satisfy the sustained motivation to feed and forage in the restricted fed sows. In any case, the reduction in stereotyping brought about by the high fibre diet in combination with access to straw can be viewed as a reduced motivation to feed and forage in the sows (Brouns *et al.*, 1994) and hence is an improvement in sow welfare.

The treatments had no effect on post mixing aggression and this was reflected in the lack of an effect on aggression related injury scores. Similarly, a previous study by Whittaker *et al.* (1999) found that increasing dietary fibre had no effect on aggression when unfamiliar sows were newly mixed. Boyle and Gauthier (2004) also found no effect on aggression at mixing of providing sows with access to straw in racks or natural fibre ropes. In that study sows were housed in the same housing system as the one used in the current trial. From these and other studies it is obvious that aggression at mixing is largely unavoidable and is indeed necessary to ensure establishment of the dominance hierarchy and to achieve group stability (Broom *et al.*, 1995). There is evidence that increasing the fibre levels in sow diets and/or providing large amounts of straw can help to reduce levels of chronic aggression in group housed sows (Meunier-Salaün *et al.*, 2001). Indeed the provision of straw in racks reduced the performance of head thrusting over the course of the experimental period and sows fed the high fibre ration showed a significant reduction in chewing of their pen mates. The straw probably provided the sows with the ability to redirect their attention to the substrate available (Beattie *et al.*, 1995) and away from their pen mates. Chewing pen mates is viewed as an anti-social or harmful behaviour (Beattie *et al.*, 2000) and a reduction in the performance of this behaviour is an improvement to sow welfare.

Sows on the high fibre ration spent proportionally more time resting with their eyes closed in the voluntary cubicles compared to sows on the control diet. Previous studies also showed an increase in resting behaviour when fibre levels in the concentrate ration were increased (Ramonet *et al.*, 1999; Matte *et al.*, 1994) and when a foraging substrate is available in racks (O'Connell, in press). The straw treatment had no effect on resting behaviour.

While active, sows provided with the high fibre diet and straw in racks showed a general increase in exploratory behaviours. This is in agreement with Durrell *et al.* (1997) who showed that providing enriching substrates to sows in small static groups increases the time spent exploring their environment. An increase in exploratory behaviour performed by sows in small static groups could

be viewed as beneficial, because such systems provide sows with less social and environmental stimulation compared to housing systems for large and/or dynamic groups (Durrell *et al.*, 2002).

Finally there were no treatment interactions on body weight change or on the final back fat level for the sows, although the sows in the high fibre treatment gained more weight over the treatment period. Increased weight gain on high fibre diets may be attributed to greater gut-fill and increase in the weight of the gastrointestinal tract (Brouns *et al.*, 1995). This is supported by the fact that there was no differences found in back fat levels.

Conclusions

Increasing the dietary fibre content of the diet and the provision of straw in racks had positive effects on sow welfare in small static groups. Sows showed a reduction in the performance of oral stereotypies such as sham chewing and bar biting. There was also a reduction in aggression in the form of head thrusting and chewing pen mates although there was no reduction in aggression in the post mixing period. The levels of general exploration also increased when the sows were active however sows on the high fibre diet spent more time resting.

6. References

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7. Publications from this project

- Stewart, C.L., O'Connell, N.E., McCann, M.E.E. and Boyle, L.A. 2010. The effect of feeding a high fibre diet on the welfare of sows housed in large dynamic groups. *Animal Welfare (In press)*.
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