Australian Government
Department of Agriculture

AUSTRALIAN Pork

Feeding Strategies to Reduce 'Frustration' and Aggression amongst Group Housed Gilts and Sows

Final Report
APL Project 2011/1023.343

April 2012

The University of Adelaide
Dr William van Wettere
Roseworthy Campus SA 5372

1. Acknowledgements

This project is supported by funding from Australian Pork Limited and the Department of Agriculture.

The author wishes to acknowledge Anthony Martyniuk who conducted this project as part of his honours degree, Tony Edwards (ACE consulting) for formulating the diets and the Lauckes feedmill for milling the feed. The technical assistance of Dave McNeil and Paul Herde, as well as the scientific input of Drs Alexandra Whittaker and Susan Hazel, are gratefully acknowledged.

2. Executive Summary

Background and Justification

In 2001, it was estimated that 62% of Australian breeding sows are housed individually in stalls (dry sow stalls; Barnett et al., 2001). However, increasing pressure from retailers and consumers is resulting in a rapid phase-out of dry sow stalls and a widespread adoption of group housing for gestating sows. Although group housing has positive welfare benefits for the sow, enabling freedom of movement and the ability to express natural behaviours, there are a number of serious negative welfare implications. In particular, competition for resources (food, space) and aggressive interactions between sows not only limit the productivity of these systems but can also counteract the welfare benefits.

Competition for resources, such as food, has been identified as a trigger of inter-animal aggression. It is current industry practice to feed sows a relatively high density, rapidly digestible diet during the first 14 –28 days post-insemination, with the aim of maximising embryo implantation and thus farrowing rates and litter sizes. However, we postulated that this strategy promotes rapid consumption of food and promotes aggressive encounters at feeding times. In addition, the rapidly digestible nature of the feed likely fails to induce feelings of satiety, resulting in increased physical activity and 'frustration' (Rijnen et al., 2003; Schneider et al., 2007) and altering time budgets in favour of aggression. Therefore, the current study tested the hypothesis that providing group housed sows and gilts with a high fibre (bulky), slowly digestible diet would reduce incidences of aggression, as evidenced by behavioural measures and injury scores, whilst maintaining reproductive output.

Experimental Methods

Conducted at the University of Adelaide's piggery, Roseworthy between May and August 2011 (autumn/winter), this experiment used 86 Large White / Landrace mated sows, with a mean parity of 2.7 ± 0.2 (range; 1 – 8) and a weaning-to-oestrus interval of 4.8 ± 0.1 days (range; 4 – 7 days). All sows were artificially inseminated at first detection of oestrus and again 24 hours later, randomly allocated to treatment and housed individually in stalls from first oestrus detection until commencement of treatments. Housing and dietary treatments commenced on day 4.8 ± 0.1 and ended on day 29 ± 0.1 post-first artificial insemination and were as follows: Low fibre diet and stall housed (**LFS**; n = 19); high fibre diet and stall housed (**HFS**; n = 19); low fibre diet in group housing (**LFG**; n = 24); and high fibre diet in group housing (HFG; n = 24). Both feeding treatments received a daily energy allowance of 32 Megajoules (MJ) of digestible energy (DE), equating to 2.5 kg / sow for the low fibre group (13.1 MJ DE/kg feed) and 4.7 kg / sow for the high fibre group (6.9 MJ DE/kg feed), with diets fed once daily on the floor of the pen. Group housing pens consisted of 6 sows per pen, with a space allowance of 1.8 m^2 / sow. Observations were conducted to determine the effect of feeding and diet on sow behaviour, with behaviours categorised as agonistic and non-agonistic for analysis. Injury scores were conducted, sow body condition was determined at start of end of treatment, with incidences of culling and reproductive failure as well subsequent litter sizes also recorded.

Results Summary

The most important finding obtained from this experiment was that feeding the high fibre diet significantly reduced the number of aggressive encounters post-feeding (equating to a 75% decrease), and resulted in a 150% increase in the time sows spent engaged in feeding behaviour. Interestingly, although group formation was associated with an increase in injury scores, there was a gradual decline from day of mixing until the end of the experimental period. In terms of production parameters, the high fibre diet resulted in a significant increase in weight gain during the experimental period (14 versus 6 kg), but no change in P2 backfat. More importantly, the incidence of culling for structural reasons and pregnancy losses on day 29 of gestation, were unaffected by diet or housing treatment. Incidences of culling and proportion of sows pregnant were as follows; 0.0 and 0.89 (Low Fibre Stalls), 0.05 and 0.89 (High Fibre Stalls); 0.13 and 0.91 (Low Fibre Group); 0.04 and 0.96 (High Fibre Group). Subsequent litter size was unaffected by housing or dietary treatment: total born was 11.5 ± 0.27 and born alive was 10.6 ± 0.31.

Conclusion and Implications

The data from this trial provides strong evidence that feeding sows a high fibre, bulky diet during the first 30 days of gestation reduces incidences of aggression during and following feeding. Importantly, the high fibre diet did not impair subsequent litter size, suggesting that increasing high fibre gestation diets can be used commercially to reduce aggression and increase satiety in group housed sows. However, it is proposed that some additional work is required prior to commercial adoption of this strategy. One, additional studies should be conducted using a larger number of animals and a number of genotypes. Two, the benefits of high fibre diets should be determined in different feeding systems (e.g. electronic sow feeders versus floor fed) and housing systems (eg substrate based versus concrete pens).

3. Background to Research

In 2001, it was estimated that 62% of Australian breeding sows are housed individually in stalls during gestation (dry sow stalls; Barnett et al. 2001). There are a number of production-related and health advantages associated with the use of dry sow stalls, including the ability to regulate the feed intake of individual sows and the minimisation of sow to sow aggression (Jansen et al., 2007). Despite the benefits, the adverse effects on sow welfare that stalls cause is becoming widely accepted by scientists, retailers and consumers. Sow movement is restricted in stalls, limiting the expression of natural behaviours and predisposing to stereotypic behaviours (Weaver and Morris, 2004). Increased incidence of leg injuries and joint conditions is also observed (Fredeen and Sather, 1978). As a result of the increased recognition of the welfare issues arising from sow stall use, there have been amendments to animal protection legislation in a number of countries. Within the EU, the use of individual stalls for pregnant sows, and gilts, during a period starting from 4 weeks after service to 1 week before the expected time of farrowing has been banned as of January 2013 (ref EC 2001/88/EC). In the United Kingdom this ban has been extended to completely exclude the use of stalls for non-lactating sows (Edwards, 1998). The Australian pork industry has also taken a proactive response by implementation of a voluntary phase out of sow stalls by 2017 (ref APL website http://www.australianpork.com.au/pages/page11.asp).

Group housing of sows from mating through to farrowing is the current alternative to sow stall systems. Group housing allows sows to express natural behaviours such as foraging, using supplied substrates (Fraser, 2008), and facilitates interaction. In groups, sows naturally form hierarchies; however, the formation is based on results of aggressive encounters (Hoy et al., 2009). Aggression is heightened when unfamiliar sows are grouped together (Hoy and Bauer, 2005). This aggression is likely to be a major stressor for sows. Aggression is also associated with physical damage (lesions and leg problems) and increased culling rates (Jansen et al., 2007, Karlen et al., 2007). Therefore in order to achieve real welfare improvements in these systems a strategy is required to minimise aggression and consequent stress. Additionally, physiological stress during early gestation is believed to elicit endocrine changes which negatively affect conception rates, farrowing rates and possibly litter size (Jansen et al., 2007). Stress due to food deprivation (as might occur in lower ranking sows), has also been shown to cause a reduction in reproductive performance. This is due to retardation of pre-implantation embryonic development, and impaired signalling between the conceptus and the maternal environment (Mburu et al., 1998). Typically pregnant sows are food restricted at 60% of their *ad libitum* intake as a mechanism to enhance reproductive performance (Ramonet at al 2000- AS 70:275-286). However, this can lead to increased levels of aggression (Jensen et al 2000), increased physical activity (De Leeuw 2005) and stereotypy development (Lawrence and Terlouw 1993).

In order to both maximise the productivity of gestating sows housed in groups and improve their welfare (by reducing stress and physical damage) it is imperative that simple, cheap and easy to implement strategies are developed which effectively reduce sow-to-sow aggression and satisfy the sows need to 'forage'. Alteration in dietary composition, as long as it incurs no increase in cost, is perhaps one of the simplest methods of achieving these outcomes.

4. Objectives of the Research Project

The primary aim of this study was to determine the effects of feeding a high fibre, low digestible energy diet during early gestation, on welfare and reproductive performance of sows housed in static groups of six animals. Welfare was assessed by analysis of behavioural parameters (with a particular focus on aggression), and by injury scoring. Stall housed animals were used as to provide a comparison control for production indices between the two housing types.

5. Introductory Technical information

Changes within the EU pig Directive have also mandated the provision of sufficient bulk or fibre in the diet to satisfy hunger, and provide chewing motivation. A number of food- related strategies to reduce aggression have been investigated. This includes the ad lib feeding of high fibre diets and the manipulation of food delivery both during, and after mixing (Peltoniemi et al., 2010, Barnett et al., 1994). It has been demonstrated that a high fibre diet results in a time allocation shift towards feeding behaviours (Ramonet et al., 1999), and that decreasing the level of digestible energy in the diet with a concurrent increase in the volume of food reduces aggressive interactions and increases feeding behaviour (Stewart et al., 2010). High fibre diets produced no negative effects on reproductive parameters when fed to stall housed animals (Peltoniemi et al., 2010). Consequently high fibre diets appear to be an effective strategy to reduce aggression in group housed animals. Few studies have considered the effects of high fibre diets on welfare and reproductive parameters in small, static-group housed animals during early gestation.

6. Research Methodology

This experiment was conducted at the University of Adelaide, Pig and Poultry Production Institute (PPPI) at Roseworthy, South Australia, with approval from the Animal Ethics Committee of the University of Adelaide. This experiment used 86 Large White cross Landrace sows, with a mean parity number of 2.7±0.2 (range 1 to 8) and a weaning to oestrus interval of 4.8±0.1 (range 4 to 7), and was conducted between May and August 2011 (autumn/winter in the Southern hemisphere).

The experimental design used was a two by two factorial, incorporating two housing types from day 4.8±0.1 up until day 29.2±0.1 post-first insemination (individual dry sow stalls versus group housing in static groups) and two dietary levels (low fibre (5%) versus high fibre (25%)). Sows were stratified according to parity and weaning-to-oestrus interval, and randomly allocated to one of the following four treatment groups; low fibre diet in stall housing- (LFS; n=19), high fibre diet install housing (HFS; n=19), low fibre diet ingroup housing(LFG; n=24) and high fibre diet ingroup housing(HFG; n=24). Sows were fed according to standard industry practice to achieve a daily energy intake of 32 megajoules (MJ) of digestible energy (DE) per day. To achieve this, sows in the low dietary fibre groups received 2.5 kg/day (13.1MJ DE) and sows in the high dietary fibre groups received 4.7 kg/day (6.9MJ DE) (Table 1). Housing treatments commenced on day 4.8±0.1 relative to first artificial insemination. Animals received a housing acclimatisation period of one day prior to commencement of dietary treatment. The dimensions of the individual dry stalls were 0.7m x 2.2m, thus allowing approximately 1.5 m^2/sow, which conforms with the current Model Code of Practice for the Welfare of Pigs. Group housing treatments consisted of six sows in pens measuring 3.6m x 3.0m, thus providing a space allowance of 1.8 m^2/sow. Pens comprised of a concrete partially slatted floor with an automated drinker. Animals were floor fed their treatment ration once daily at 0800h. At the end of the treatment period, day 29.2±0.1 of gestation, sows were moved to straw based group accommodation, with 40 sows / pen. Four replicates were performed over the four months of the experiment with equal numbers of animals assigned to each replicate.

Measurements

In order to determine the effect of the dietary treatments on sow behaviour in response to feeding and mixing, behavioural observations no group housed animals were conducted on days 0, 3, 7, 14 and 21 post mixing (where day 0 = day of mixing). Observations were made based on an established ethogram (Stewart et al., 2008), Behaviours were categorised and grouped as agonistic or non-agonistic for analysis. Instantaneous scan sampling of the group, by casual observer, was performed at set intervals. . On day zero, observations were made at 15 minute intervals for the first two hours post-mixing, and then every 30 minutes for the following four hours. On days 3, 7, 14 and 21 post mixing, observations were made at 0, 30, 60, 90 and 120 minutes post-feed delivery to determine response to feeding. On days 7, 14 and 21 post-mixing, additional observations were made at 30 minute intervals between 1400h and 1600h to obtain an indication of unstimulated behaviours.

An injury scoring method was used to serve as an indicator of the severity of aggressive encounters. This system was a modified version of the scheme developed by Karlen *et al.* (2007). The total number of injuries (scratches, abrasions and ulcers) were recorded for the body as a whole. Scoring was conducted on the day of mixing (zero, two and six hours post-mixing), and during feeding on days 3, 7, 14 and 21 post mixing.

Table 1: Ingredients used to formulate low and high fibre diets

Main materials	Low fibre diet	High fibre diet
	%	%
Betafin	0.42	
Alimet	0.02	
Threonine	0.03	
Biofos	0.80	
Wheat fine	19.00	
Wheat mil vits	1.00	
Barley fine	10.00	
Triticale	31.50	
Peas fine	2.50	
Tallow mixer	0.50	
Canola meal	2.00	
Millrun	26.84	
Meatmeal	3.07	3.00
Salt	0.30	0.40
Limestone	1.33	0.90
Lysine	0.25	0.11
Biofix Plus	0.20	0.15
Breeder+Bioplex	0.25	0.20
Oat hulls		14.00
Cereal straw		40.00
Oats		13.40
Lupins		10.00
Dicalphos		0.80
Millmix		17.00
Methionine		0.05
Choline Chloride 75%		0.05
Analysis		
Protein (g/day)	355	494
Fibre (g/day)	120	1180
DE (MJ/day)	32.8	32.4

On day 29.2±0.1 post-mating transcutaneous ultrasound was conducted by a commercial contractor to determine pregnancy status. Pregnancy status was recorded for all treatment groups. Production data obtained after farrowing included: litter size, total piglets born per sow, piglets born alive, and the number still born or mummified.

Sow weight and P2 backfat was measured one day prior to treatment commencement , and 29.2±0.1 days post mating. P2 backfat was measured over the last rib, 60 mm ventral to the vertebra using a 5 MHz linear probe (Aquila Vet, Pie Medical Equipment). The number of animals culled for structural reasons; which included lameness, severe injury or other medical condition was recorded.

Statistical Analysis

Values in the text are expressed as mean ± standard error of the mean (SEM). To determine the effect of high fibre diet a general linear regression was used with type three sums of squares to remove the order effect. For the effect on production and reproductive parameters treatment, parity and replicate were used. A back wise elimination was carried out with a significance of 0.05. The marginality of Nelder (1994) was observed for this model development process. Probability values <0.05 were described as significant. Data was analysed using SPSS version 18 (SPSS, Chicago, IL, USA).

For behavioural observations, the effects of treatment, parity, day, replicate and event on aggression was tested. Activity was expressed as a proportion of total available time intervals based on the number of scans conducted across the experimental period

7. Results

Within housing treatment, sows fed the high fibre diet gained significantly ($P < 0.05$) more liveweight compared to those fed the low fibre diet, with the high fibre diet resulting in an increased liveweight gain of 11kg and 6kg, in the group and stall housed treatments respectively, (Table 3). Housing treatment had no significant effect on liveweight gain, P2 backfat change was unaffected by housing or dietary treatment. No significant effect of diet or housing treatment on the proportion of sows culled for structural reasons, or on pregnancy status at day 29.1 ± 0.1 post- first insemination, was observed (Table 3). Subsequent litter size was similar for all treatments (Table 3).

Table 3: Liveweight, body condition, culling rates and reproductive performance of sows housed in stalls versus groups and fed a low versus high fibre diet. Results presented as mean ± standard error of the mean (SEM)

Housing treatment	Individual stall housing		Group pen housing	
Dietary treatment	Low fibre (n = 19)	High fibre (n = 19)	Low fibre (n = 24)	High fibre (n = 24)
Parity	2.7±0.4[a]	2.9±0.4[a]	2.7±0.4[a]	2.6±0.4[a]
Weaning to oestrus (days)	4.9±0.2[a]	4.9±0.2[a]	4.7±0.1[a]	4.7±0.1[a]
liveweight day 0 (kg)	235.7±6.1[a]	230.4±6.1[a]	229.4±5.4[a]	228.1±5.4[a]
liveweight day 26 (kg)	241.0±5.9[a]	241.2±6.1[a]	235.9±5.6[a]	244.2±5.4[a]
liveweight Change (kg)	6.4±2.5[a]	12.4±2.5[b]	6.0±2.3[a]	16.9±2.2[b]
P2 day 0 (mm)	22.2±1.0[a]	23.3±1.0[a]	20.7±0.9[a]	21.1±0.9[a]
P2 day 26 (mm)	21.2±4.7[a]	19.9±4.9[a]	28.7±4.5[a]	21.3±4.3[a]
P2 Change (mm)	-1.0±0.9[a]	-1.8±-1.0[a]	-0.9±-0.9[a]	-0.1±-0.8[a]
Culled (structural*)	0.00[a]	0.05[a]	0.13[a]	0.04[a]
Proportion sows pregnant	0.89[a]	0.89[a]	0.91[a]	0.96[a]
Subsequent litter size				
Total born	11.3 ± 0.57	11.8 ± 0.57	11.6 ± 0.49	11.3 ± 0.50
Born alive	10.7 ± 0.68	10.6 ± 0.68	10.7 ± 0.59	10.3 ± 0.60

*Structural reasons for removing from trial are lameness or other serious injury or medical condition . [ab] different superscripts, within row, indicate significant difference P<0.05

Based on the instantaneous scan sampling method used here, the feeding of high fibre diet significantly (P<0.05) reduced the number of aggressive encounters post-feeding, over the whole period of the study; a 75% reduction in aggression per observation in comparison to the control (low fibre) group (Figure 1). Afternoon measures were taken as baseline since there was no added stimulus for aggressive interaction. No significant effect of diet on observed incidences of aggression was noted during the afternoon period. High fibre diet provision also led to a significant increase in the proportion of behavioural observation time that animals spent engaged in feeding behaviour (150% increase) (Figure 2).

A significant (P<0.05) effect of diet was observed on the time spent feeding during the afternoon, with sows on the high fibre diet spending 20% of their time feeding, whereas no feeding behaviour was observed in sows fed the low fibre diet (Figure 2).

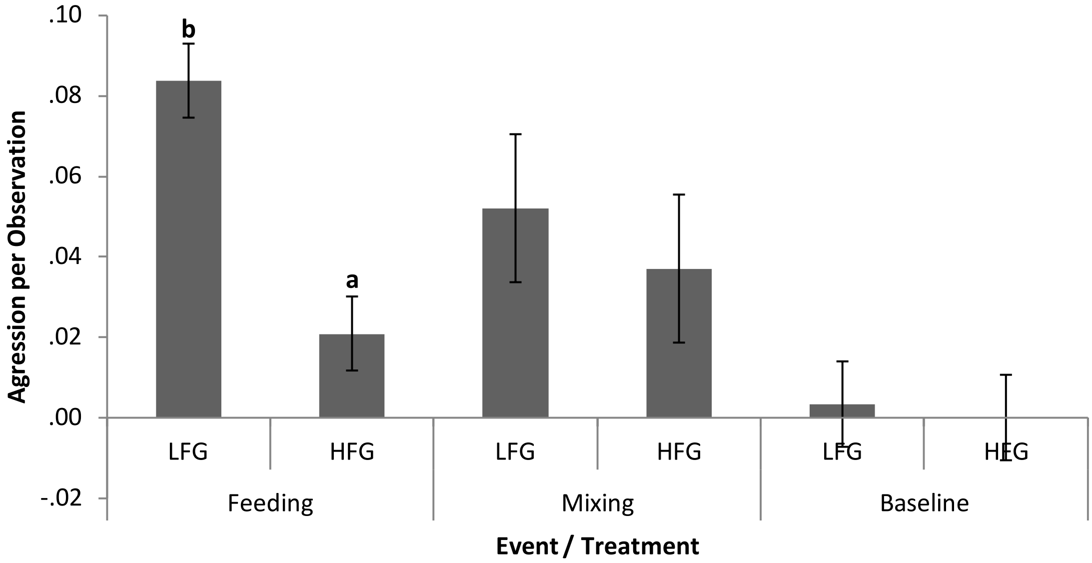

Figure 1: Graph showing percentage of total observation events that animals were engaged in aggressive behaviour, as a function of time post significant event (mixing or feeding) or during the afternoon when no external event occurred. Results presented as mean ± standard error of the mean (SEM) for the group across all observational bouts within the study. Different superscripts, within event indicate significant difference (P<0.05)

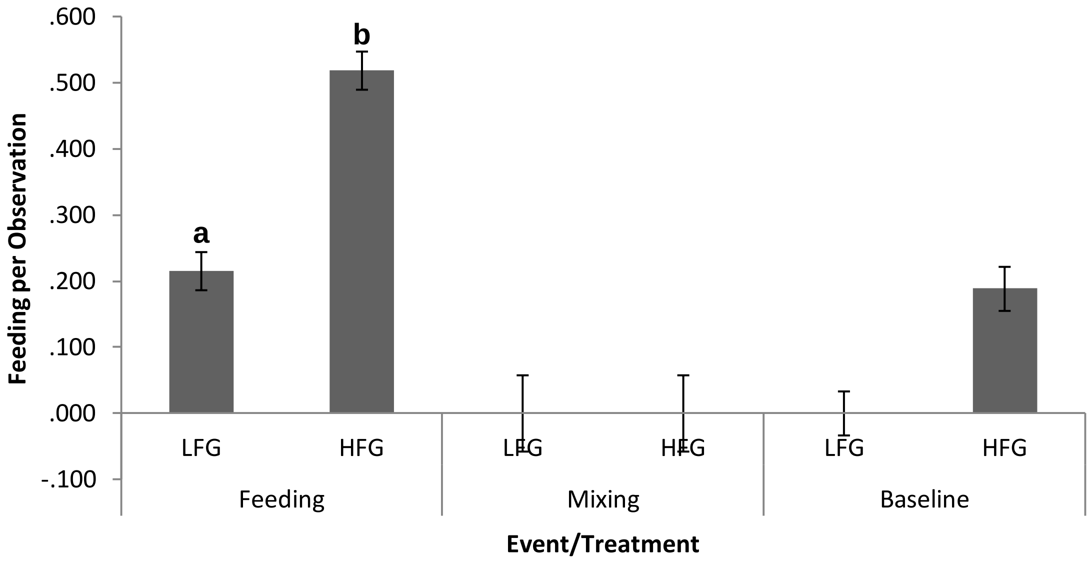

Figure 2: Graph to show percentage of total observation events that animals were engaged in feeding behaviour, as a function of time post significant event (mixing or feeding) or during the afternoon when no external event occurred. Results presented as mean ± standard error of the mean (SEM) for the group across all observational bouts within the study. Different superscripts, within event indicate significant difference (P<0.05)

There was no significant (P<0.05) difference in injury scores between treatments on any day of the study (Table 4). Injury scores increased on the day of mixing from 0 to 3. The injury scores then declined over the experimental period from day 3 to 21, from a score of 2 down to 1.

Table 4: Injury scores of sows housed in groups fed a high or low fibre diet

Day*	Treatment	
	Low Fibre (n = 43)	High Fibre (n = 43)
0-0hr	0.21±0.1[a]	0.04±0.1[a]
0-2hr	2.04±0.3[a]	2.08±0.3[a]
0-6hr	2.79±0.3[a]	2.71±0.3[a]
3	2.04±0.3[a]	2.08±0.3[a]
7	1.67±0.3[a]	1.79±0.3[a]
14	1.00±0.2[a]	1.17±0.2[a]
21	0.78±0.2[a]	0.83±0.2[a]

*Three injury scores were taken on the day of mixing at zero, two and six hours. Injury scores on days 3,7,14 and 21 were taken at the time of feeding. Different superscripts, within rows indicate a significant difference(P<0.05)

8. Discussion of Results

The current data indicates that feeding sows a high fibre, bulky diet during the first 29 days of gestation reduces incidence of aggression post-food provision. This decrease is considerable based on the behavioural sampling method used leading to a 75% reduction. Interestingly, especially in light of recent EU pig welfare legislation amendments pertaining to encouragement of chewing behaviour, there was a shift in the ethogram observed towards increased feeding behaviour (150% increase) on the high fibre diet. This shift is likely to reduce the total amount of time spent on agonistic interactions as well as satisfying the pig's natural desire to chew. It could also induce a feeling of satiety which improves welfare outcomes. This hypothesis has been suggested by Ramonet (1999) who observed reduced exploratory activity on a high fibre diet, a behaviour which is thought to indicate the need to forage or feed (Lawrence and Terlouw 1993). These observations provide support for the notion that the feeding of a high fibre diet improves sow welfare in a group housed situation.

It was apparent from the behavioural observations, that despite once daily feeding, the volume of food provided was sufficient to maintain the feeding behaviours for the duration of the day. In order to ensure a similar daily energy intake for both treatments, sows received a greater volume of the high fibre diet. Competition for limited resources is the main cause of sow-to-sow aggression (Andersen et al., 2000). It is, therefore, suggested that the increase in available feed was responsible, at least partly, for the reduced aggression of sows fed a high fibre diet. Mechanism of food supply is also likely to have an effect on outcomes. Stewart et al. (2010) used electronic sow feeders to deliver feed, enabling sows to gain access to their daily ration at any time during the day. In contrast, for the current study, sows received their entire daily allowance at a single time point with feed spread on the floor. This is likely to engender competition over food which becomes a limiting resource. However, the increased volume of food provided is postulated to have lessened competition by ensuring availability over the whole day. However, it has also been shown that once daily feeding of a high fibre diet is more effective at reducing feeding motivation than the same amount presented as two meals (Robert et al 2002; Holt at al 2006). Indeed, Stewart (2011), postulated that their use of twice daily feeding may have reduced gut fill effects in the high-fibre groups and led to a lack of predicted effect of this diet on stereotypical behaviour. Our findings concur with those of Holt et al. (2006) who showed that increasing the volume of food through inclusion of fibre, increased the proportion of time sows spent feeding. This study demonstrated a 150% increase in feeding behaviour when sows received the high fibre diet. This is expected given the increased volume of feed being supplied. Similarly, (Danielsen and Vestergaard, 2001) found that feeding time during gestation was increased by approximately 30% using a high fibre diet

For inclusion of a high fibre diet to be effective for use in a commercial setting it must not negatively affect production. Our results support this assertion. Pregnancy status on day 28 of gestation was similar for the individual and group housed sows, and was unaffected by diet. In support of this Peltoniemi et al. (2010) demonstrated that reproduction was not compromised when group housed sows received a high fibre diet, comprising of a combination of sugarbeet pulp (20%), crushed soybean (6%), oats bran (14%) and oats (10%). Sows fed high fibre diets gained significantly more weight during the experimental period than those fed the low fibre, or standard, gestation diet. However, it is hypothesised that the increased weight gain is due to increased gut fill and greater water absorptive capacity of the high fibre diet. The combination of these would increase the retention time of the feed. Further, the energy intake of the two dietary groups was balanced, and the lack of an effect of diet on P2 backfat change during the experimental period supports the suggestion that increased gut fill, as opposed to any change in lean muscle or fat deposition were responsible for the increased liveweight gain of high fibre fed sows. This finding is in contradiction to the work of Holt *et al* (2006) which showed that a low fibre diet resulted in increased weight gain (Holt et al., 2006). However, the dietary fibre source used (soybean hulls) differed from that used in this trial.

9. Implications and Recommendations

The current findings support the hypothesis that feeding group-housed sows a high fibre diet, during the first four weeks of gestation, reduces the incidence of aggression without affecting reproductive performance. A behavioural shift towards increased time spent feeding was also observed and this is likely to contribute towards reduced aggression incidence as well as promoting positive porcine behaviours (chewing). It is proposed that these behavioural shifts reflect the pig's change in perception of food with it no longer being seen as a limited resource. Additionally, production and reproductive parameters were maintained. Therefore feeding group housed sows a high fibre diet had a positive effect of welfare as evidenced by reduced aggression and increased feeding behaviours. The feeding of a high fibre diet may thus represent an inexpensive strategy to improve sow welfare, whilst maintaining production capability. However, further studies are needed with increased number of animals to investigate this fully and to optimise this strategy for commercial use. In particular, further directions for this work should include investigation of the optimal dietary fibre content to minimise aggression, and evaluation of different feeding regimes, such as decreasing the feeding interval or using trickle feeders. An assessment of the relative contribution of fibre and food volume towards the positive behavioural responses seen would also be of merit, as would determining the benefits of high fibre diets in different housing systems (eg substrate based versus concrete pens).