Nutritional Management Strategies to reduce aggression at mixing of unfamiliar sows

1C-115

Report prepared for the

Co-operative Research Centre for High Integrity Australian Pork

T.L. Muller[1], R.J.E. Hewitt[1] and R.J. van Barneveld[1,2]

[1]CHM Alliance Pty Ltd., P.O. Box 4477, Loganholme DC QLD, 4129

[2]Barneveld Nutrition Pty Ltd., P.O. Box 4477, Loganholme DC QLD, 4129

Ph: 07 4630 6746

Fax: 07 4630 6321

E-mail: tmuller@chmalliance.com.au

February 2015

Established and supported under the Australian Government's Cooperative Research Centres Program

Executive Summary

There is evidence that aggression and fighting in sows at mixing may be reduced in group housing systems by the provision of enrichment (Schaefer *et al.*, 1990; Beattie *et al.*, 1995; Durrell *et al.*, 1997). Furthermore, the inability of sows to exhibit natural foraging behaviour and feel satiated once established in group housing can accentuate ongoing inter-sow aggression (Danielsen *et al.*, 2001). By enriching the environment and providing opportunity for foraging, we may not only improve sow welfare but also allow for the provision of nutritional satiety through the inclusion of fibrous components into the sows' diet. This project compared strategies for reducing aggression at mixing of sows by 1) a higher feeding level and the use of enrichment in the form of a supplemental nutrient Block, and 2) feeding a diet containing Sugarbeet pulp (SBP) and Magnesium oxide (MGO), alone or in combination, prior to and during mixing.

The experimental design for Experiment One and Two followed a similar strategy, 36 non-reproductive sows and gilts were randomly allocated to experimental groups. Six multi-parous sows were pseudo-randomised into one of either three (Exp 1) or four (Exp 2) experimental groups for six replicates. Experiment One, investigated two strategies; either providing a supplemental block as enrichment or a higher feeding level. A common dry sow diet was fed to three treatment groups (1) a control group fed at 2.3 kg/sow/day; (2) a block enrichment group (1 x 30 kg poured block) was also fed at 2.3 kg/d and (3) a higher feed group which received 4.0 kg/sow/day. Experiment Two investigated dietary inclusions in a 2 x 2 factorial design resulting in four treatment groups (1) a control diet (no additional inclusions); (2) Sugarbeet pulp at an inclusion of 20 %; (3) Magnesium oxide at an inclusion of 0.2 %; and (4) a diet containing both 20 % Sugarbeet pulp and 0.2 % Magnesium oxide. Each experimental replicate ran for 7 days. During days 1-3 (Exp 1) or 1-4 (Exp 2), sows were housed in individual stalls and fed 2.3 kg/day. The experimental dietary treatments were imposed on day 4 in Experiment 1 and were imposed on day 1 in Experiment 2. Immediately following this, on Day 4 (Exp 1) or 5 (Exp 2), sows were introduced into treatment pens before 7.00 am for an observational period of 4 (Exp 1) or 3 days (Exp 2). Sows were then returned to individual stalls for the next replicate, each time running for 7 days. Daily data collection during the observational period involved; behavioural and posture observations, individual sow scratch injury scores to measure the prevalence of agonistic behaviour, and saliva samples to analyse salivary cortisol levels as an indication of stress response to mixing.

It was found in both experiments that the display of aggression associated with feeding was constant across treatment groups. However, there was a significant effect of treatment on the display of chase behaviour in Experiment One, as it appeared to be positively affected by the presence of a block supplement or a higher feeding level. Sows also tended to spend less time foraging and more time lying, 1 h after feeding, in both these treatments. In Experiment Two, the inclusion of sugarbeet pulp and/or magnesium oxide in the diets of sows failed to have any significant effect on any of the behavior or welfare parameters that were measured in the experiment.

The mean time sows spent fighting was greatly reduced within the first 24 h of mixing in both experiments, as hierarchy positions in groups of sows are settled quickly. Chase and threat behaviours appeared to illustrate a pattern which became significant in Experiment Two with chase behaviour appearing to increase the day after mixing, before falling again the following day. Although threat behaviour increased overtime in Experiment Two, this may be expressed as a less aggressive behaviour performed mostly once hierarchal positions have been established in the first days after mixing. Fresh scratch injuries and salivary cortisol were not affected by experimental treatment, but fresh scratch injuries decreased over time in both studies. Salivary cortisol levels did appear to increase over time in Experiment Two, which appears in conflict with other observations as the prevalence fighting and fresh scratch injuries actually decreased.

Table of Contents

1. Introduction

The recent transition from individual housing during early gestation to group-housing has seen many different gestation housing systems adopted. This transition has seen it become common practice to mix sows. Sows, especially those which are unfamiliar with each other, will often fight when housed together often resulting in injury and lameness. Environmental enrichment has been shown to reduce, and prevent abnormal and harmful behaviours as well as improve health and performance (Jones *et al.*, 2000). The provision of an enriched environment with the addition of spent mushroom compost has been shown to reduce aggression in loose-housed dry sows (Durrell *et al.*, 1997). However, the majority of research investigating environmental enrichment in intensive pig husbandry focuses on the growing herd. Any enrichment program needs to be compatible with the daily operations of the farm; therefore, it should be cost effective, simple, compatible with management, effective and ongoing.

Experiment One aimed to evaluate as an "enrichment product", a poured supplemental block, formulated for maximum attractiveness and most importantly, hardness to ensure its longevity. Prior work conducted by CHM Alliance Pty Ltd and industry partners has tested different block formulations to investigate longevity, attractiveness and delivery methods. The result has been the development of a block suitable for group pens which requires no alterations to housing or maintenance and can be utilised by more than one sow at a time.

Whilst the use of electronic sow feeders has seen changes to the standard feeding programs for gestating sows, simpler systems often still consist of a restricted amount of feed delivered once or twice daily. In this situation, diets are generally consumed within minutes, do not provide satiation and result in feeding motivation remaining high. This may then accentuate inter-sow aggression in group-housing systems (Bergeron *et al.*, 2000). One method that has been employed to try to meet nutritional satiety is the provision of higher feeding levels, which reduces competition and feeding and allows sows the opportunity to forage for longer periods of time throughout the day.

Experiment One investigated two strategies involving satiety and enrichment components with the aim of reducing aggression at mixing of sows, with the enrichment component also providing longer term reduced aggression through reducing feeding frustration.

Nutritional satiety can also be achieved through the addition of a fibrous component into the diet. The general effect of fibrous diets offered to sows has been widely documented (Meunier-Saün *et al.*, 2001; de Leeuw *et al.*, 2008; Bergeron *et al.*, 2000), but to date the only real success has been with Sugarbeet pulp (SBP). It has been found that this fibrous ingredient can induce significant behavioural changes that could be indicative of a higher degree of satiety and also reduce aggression (Danielsen and Vestergaard, 2001).

It was found from Pork CRC funded experiment in Project 1C-106, that an inclusion rate of 20 % SBP into the diet resulted in an increase in lying behaviour and time taken to consume the meal. The fermentable fibre contained in this product is thought to delay the rate of passage of digesta and nutrient absorption and shift fermentation towards the hindgut. The shift to hindgut fermentation and improved gut health allows the proliferation of beneficial bacteria which produce high levels of VFAs. This VFA production may also impact satiety as it can play a role in stabilising blood glucose and insulin levels (Bo and Pisu, 2008).

Another dietary ingredient, magnesium oxide (MGO), has been suggested to play a role in insulin resistance (Barbagallo *et al.,* 2003). Stabilising insulin levels will in turn stabilise blood glucose levels, as insulin is a facilitator for circulating blood glucose through the bloodstream. Results from Project 1C-106 also indicated that an inclusion rate of 0.1% MGO, tended to increase overall lying behaviour. These results provided a base for Experiment Two, in which we investigated including either 20% SBP or 0.2% MGO into the diet for only on those days just prior to and during mixing of unfamiliar sows. The possibility of feeding SBP and or MGO on only those days when aggression is displayed most frequently after mixing will limit any increase in sow feed costs to a week or so around the mixing period.

2. Methodology

Experiment One

The use of a poured supplemental block and higher feeding levels to reduce aggression and provide enrichment for sows in groups

This experiment investigated two strategies to reduce aggression at mixing, either providing a supplemental block as enrichment, or high feeding levels at mixing. These strategies were expected to reduce aggressive behaviours and enhance the display of exploratory and foraging behaviours. The inclusion of ingredients, previously investigated in satiety studies, within the block was also expected to increase inactivity or lying behaviour. A common dry sow diet was fed to all treatments (Table 1), with the control group fed at 2.3 kg/sow/day, The block enrichment group (1 x 30 kg poured block) was also fed at this level, whilst the higher feed group received 4.0 kg/sow/day. The block was formulated to include Sugarbeet pulp (SBP) and Magnesium oxide (MGO) shown to induce satiety in previous work (Pork CRC 1C-106), in a molasses and salt base.

Experimental Design

The study was conducted at the Westbrook research facility. As this was a study looking at behavioural interactions at mixing, having static groups would result in familiarisation between sows. Consequently 36 non-reproductive sows and gilts were included in the study and allocated to the experimental groups as per the treatment matrix (Table 2) where a cross over design was used to pseudo-randomise six multi-parous sows into one of the three experimental treatment groups for six replicates (n=36). Each experimental replicate ran for 7 days. During days 1-3, sows were housed in individual stalls and fed 2.3 kg per day. Adjoining stalls were left empty to reduce interactions and familiarisation between sows. On Day 4, sows were introduced into one of three treatment pens before 7.00 am for a 4-day observation period, as per treatment matrix.

The experimental unit was the pen of 6 sows that were mixed into a group on the morning of Day 4. The experimental treatment groups were:

- Control: 2.3 kg/sow/day of dry sow diet, floor fed in two places at 0700 hrs after mixing on Day 4.
- Block enrichment: 2.3 kg/sow/day of dry sow diet, floor fed in two places at 0700 hrs. A 30 kg supplemental block was placed in center of pen (not fixed) on Day 4 and weighed daily after mixing.
- High feeding level: 4 kg/sow/day, floor fed out at maximum dispersal around pen at 0700 hrs after mixing.

Table 1 - Formulation and analysis of dry sow diet fed to all treatments to investigate the effects of high-feeding level or the use of a supplement block to reduce aggression in mixed sows.

Ingredients		
Barley	(%)	11.3
Sorghum	(%)	59.7
Millrun	(%)	20.0
Blood meal	(%)	0.67
Meat meal	(%)	2.00
Molasses	(%)	2.00
Limestone	(%)	1.81
Dicalphos	(%)	1.07
Salt	(%)	0.30
Potassium chloride	(%)	0.33
Choline chloride	(%)	0.05
Betaine	(%)	0.15
MHA calcium	(%)	0.02
Lysine HCl	(%)	0.3
L-Threonine	(%)	0.02
Mycotoxin binder	(%)	0.1
Vitamin/Mineral premix	(%)	0.2
Analysis		
Dry Matter	(%)	87.7
Moisture	(%)	12.2
Crude Protein	(%)	12.6
Crude Fibre	(%)	3.9
Energy (Digestible)	(MJ DE) (%)(%)	12.8
Lysine	(%)	0.65
Calcium	(%)	1.20
Available Phosphorus	(%)	0.40
Cal:Av Pho		2.99
Fat	(%)	2.90
Available Lysine/MJ DE	(g/MJ DE)	0.41

After 4 days, sows were returned to individual stalls for the next replicate (3 days in individual stalls followed by 4 days in the experimental treatment pens). This was repeated six times to obtain 6 replicates of each treatment. During the 4-day observation period (Days 4 to 7, inclusive), groups were stocked at a density of $1.8m^2$/sow and fresh water made available *ad libitum* via a nipple drinker.

Daily data collection during the 4-day observation period involved; measurement of block weight (the block was weighed daily at 0700 hrs), behavioural and posture observations, individual sow scratch scores to measure the prevalence of aggressive behaviour, and salivary cortisol samples.

Table 2 - Treatment structure for pseudo-randomised cross-over design to investigate the effects of high feeding level (High feed) or the use of a supplement block (Block) to reduce aggression in mixed sows compared to an untreated control (Control).

Replicate	Treatment	Sow…					
1	Control	1	2	3	4	5	6
	Block	7	8	9	10	11	12
	High feed	13	14	15	16	17	18
2	Control	31	32	33	34	35	36
	Block	19	20	21	22	23	24
	High feed	25	26	27	28	29	30
3	Control	2	8	14	20	26	32
	Block	3	9	15	21	27	33
	High feed	1	7	13	19	36	31
4	Control	4	10	16	22	28	34
	Block	5	11	17	23	29	35
	High feed	6	12	18	24	30	25
5	Control	3	10	17	24	36	32
	Block	1	8	15	22	29	25
	High feed	2	9	16	23	30	31
6	Control	5	12	13	20	27	34
	Block	6	7	14	21	28	35
	High feed	4	11	18	19	26	33

Experiment Two:

The response of group-housed sows to the inclusion of Magnesium oxide and Sugarbeet pulp in dry sow diets

This experiment investigated the addition of Sugarbeet pulp (SBP) and Magnesium oxide (MGO) into the diet prior to, and during mixing of unfamiliar sows. These strategies were expected to reduce aggressive behaviours and increase inactivity or lying behaviour. Experimental treatments consisted of (1) a standard control diet (no supplement); (2) Sugarbeet pulp at an inclusion rate of 20 %; (3) Magnesium oxide at an inclusion rate of 0.2 % and a (3) a diet containing both 20 % Sugarbeet pulp and 0.2 % Magnesium oxide (Table 3).

Experimental Design

The experimental design followed that similar to Experiment One. This study was conducted at the Westbrook research facility using a population of 36 non-reproductive sows and gilts allocated to the experimental groups as per the treatment matrix (Table 4). A total of 24 sows, selected from the 36 sows available, were used for each replicate.

A 2 x 2 factorial design was used to pseudo-randomise six multi-parous sows into one of the four experimental treatment groups for six replicates. Each experimental replicate ran for 7 days. During days 1-4, sows were housed in individual stalls and fed 2.3 kg per day of the allocated diet. Adjoining stalls were left empty to reduce interactions and familiarisation between sows. On Day 5, sows were introduced into one of four treatment pens before 7.00 am for a 3-day observation period, as per treatment matrix.

The experimental unit was the pen of 6 sows that were mixed into a group on the morning of day 5. The experimental treatments groups were:

- Control: 2.3 kg/sow/day of dry sow diet, fed at 07.00 am whilst housed in individual stalls for days 1-4 and floor fed in two places on experimental days 5-7.
- SBP: 2.3 kg/sow/days of treatment diet, fed at 07.00 am whilst housed in individual stalls for days 1-4 and floor fed in two places on experimental days 5-7.
- MGO: 2.3 kg/sow/day of treatment diet, fed at 07.00 am whilst housed in individual stalls for days 1-4 and floor fed in two places on experimental days 5-7.
- SBP+MGO: 2.3 kg/sow/day of treatment diet, fed at 07.00 am whilst housed in individual stalls for days 1-4 and floor fed in two places on experimental days 5-7.

Table 3 - Formulation and analysis of treatment diets; Control, Sugarbeet pulp (SBP), Magnesium oxide (MGO) and Sugarbeet pulp with Magnesium oxide (SBP+MGO).

Ingredients		Control	SBP	MGO	SBP+MGO
Sorghum	(%)	69.2	59.4	69.0	59.2
Millrun	(%)	20.0	10.7	20.0	10.7
Sugarbeet pulp	(%)		20.0		20.0
Magnesium oxide	(%)			0.2	0.2
Soybean meal	(%)	3.0	5.1	3.0	5.1
Meat meal	(%)	2.0	1.7	2.0	1.7
Limestone	(%)	1.81	0.58	1.81	0.58
Dicalphos	(%)	1.14	1.34	1.34	1.34
Salt	(%)	0.27	0.20	0.27	0.20
Potassium chloride	(%)	0.34	0.34	0.34	0.34
Choline chloride		0.05	0.07	0.05	0.07
Betaine	(%)	0.15	0.15	0.15	0.15
MHA calcium	(%)	0.01	0.02	0.01	0.02
Lysine HCl	(%)	0.27	0.20	0.27	0.20
Bentonite	(%)	1.5	0.15	1.51	0.15

Ingredients		Control	SBP	MGO	SBP+MGO
Biofix/Mycofix plus	(%)	0.1	0.1	0.1	0.1
BN Breeder Premix	(%)	0.2	0.2	0.2	0.2
Analysis					
Dry Matter	(%)	88.1	88.0	88.0	88.0
Moisture	(%)	11.8	11.9	11.8	11.9
Crude Protein	(%)	13.1	13.1	13.1	13.1
Crude Fibre	(%)	3.6	6.0	3.6	6.0
Energy (Digestible)	(MJ/kg)	12.8	12.8	12.8	12.8
Lysine	(%)	0.64	0.70	0.64	0.70
Calcium	(%)	1.20	1.00	1.20	1.00
Phosphorus	(%)	0.70	0.63	0.70	0.63
Available Phosphorus	(%)	0.40	0.40	0.40	0.40
Cal:Pho		1.71	1.56	1.70	1.56
Cal:Av Pho		2.99	2.51	2.99	2.51
Choline	(mg/kg)	992	1001	991	1000
Fat	(%)	2.99	2.66	2.99	2.66
Omega-3	(%)	0.11	0.08	0.11	0.08
Omega-6	(%)	1.14	0.88	1.14	0.87
Available Lysine	(%)	0.40	0.40	0.40	0.40
Methionine:Lysine Methionine: Lysine		0.30	0.30	0.29	0.30
Met+Cys:Lysine		0.65	0.61	0.65	0.61
Tryptophan:Lysine		0.20	0.19	0.20	0.19
Threonine:Lysine		0.66	0.67	0.66	0.67
Isoleucine:Lysine		0.76	0.74	0.76	0.74

After 3 days, sows were returned to individual stalls for the next replicate (4 days in individual stalls followed by 3 days in the experimental treatment pens). This was repeated six times to obtain 6 replicates of each treatment. During the 3-day observation period (Days 5 to 7, inclusive), groups were stocked at a density of $1.8m^2$/sow and fresh water made available *ad libitum* via a nipple drinker.

Daily data collection during the 3-day observation period involved; behavioural and posture observations, individual sow scratch scores to measure the prevalence of aggressive behaviour, and salivary cortisol samples.

Table 4 - Treatment structure for pseudo-randomised cross-over design to investigate the effects on aggression in mixing of unfamiliar sows when fed a diet containing 20 % Sugarbeet pulp (SBP), 0.2 % Magnesium oxide (MGO) and 20 % Sugarbeet pulp + 0.2 % Magnesium oxide (SBP+MGO) compared to a control diet (Control).

Replicate	Treatment	Sow…					
1	Control	1	2	3	4	5	6
	SBP	7	8	9	10	11	12
	MGO	13	14	15	16	17	18
	SBP+MGO	19	20	21	22	23	24

Replicate	Treatment	Sow…					
2	Control	2	8	14	20	26	32
	SBP	25	26	27	28	29	30
	MGO	31	32	33	34	35	36
	SBP+MGO	1	7	13	19	25	31
3	Control	5	11	17	23	29	35
	SBP	6	12	18	24	30	36
	MGO	3	9	15	21	27	33
	SBP+MGO	4	10	16	22	28	34
4	Control	2	9	16	23	30	31
	SBP	3	10	17	24	25	32
	MGO	4	11	18	19	26	33
	SBP+MGO	1	8	15	22	29	36
5	Control	5	12	13	20	27	34
	SBP	6	7	14	21	28	35
	MGO	2	4	6	8	10	12
	SBP+MGO	14	16	18	20	22	24
6	Control	25	27	29	31	33	35
	SBP	26	28	30	32	34	36
	MGO	1	3	5	7	9	11
	SBP+MGO	13	15	17	19	21	23

Behavioural Observations

Behavioural recordings consisted of pen video monitoring during the 4-day (Experiment One) or 3-day (Experiment Two) observation periods. Daily observations during these periods began upon entry into the pen (0700 hrs) and for a period of 1 hr after feeding. Behaviour and posture activity was recorded by scan sampling at 1 min intervals at the playback of recorded videos, according to a standard ethogram (Table 5). Time spent engaged in push, chase, attack, bite and threat behaviours were considered agonistic behaviour.

Table 5 - Ethogram used for recording sow activity in a study to investigate the effects of high-feeding level, the use of a supplement block, the addition of 20 % Sugarbeet pulp or 0.2 % magnesium oxide, in isolation and combination, into a diet to reduce aggression in mixed sows.

Postures	
Standing	Body supported by all four legs
Sitting	Body supported by the forelegs, hind legs are flat on ground
Lying	Lying with chest and stomach flat on floor, head held up off the floor or lowered
Behaviours	
Push	Using nose or head to exert force on another sow
Chase	Movement of pursuit towards another sow using a fast paced continuous locomotion which displaces the sow

Attack	Forceful violent movement towards neighbor to initiate a fight
Bite	Use of teeth to grip another sow aggressively
Threat	Sudden head movement or move towards another sow which submitted or retreated without contact being made
Sham-chewing	Continuous chewing movement with mouth while no feed or substrate is present in the mouth
Foraging	Eating or searching for substrate from ground to ingest or eat

Salivary Cortisol and Scratch Injuries

Individual, fresh scratches were counted at 0800 hrs on the day after mixing (Experiment One, Day 5 and Experiment Two, Day 6) and again on the final day of observation, Day 7 of each experimental week. Data were pooled to provide a scratch score per treatment group per day.

Saliva samples were collected from each sow during each treatment period at three time periods; Day 1 (baseline), Day 4 (Experiment One) or Day 5 (Experiment Two) at mixing and on Day 7. All sampling took place at 1000 hrs, 3 h after feeding, with method of collection and staff members used remaining consistent throughout both experiments. The individual samples were pooled on a treatment basis and analysed for cortisol as an indicator of the stress response to mixing.

Statistical Analysis

Observed behavioural parameters were grouped into two categories, postures and agonistic behaviour, and expressed as the mean relative number of 1 min intervals of occurrences. Behaviours, foraging and sham chewing, were analysed individually. With group being the experimental unit, groups totals were calculated from individual sow data and analysed for the effects of dietary treatment, period and day, as well as interactions, using Univariate General Linear Model (Genstat v15.0 VSN International, Hemel Hempstead, UK) to examine the effects on time spent displaying agonistic behaviour and postures.

In order to meet requirements of normally distributed data, data was checked for normality. Period, the effect of time, was a blocking factor for treatment effects. Scratch injuries were pooled at a pen level and analysed using the same model. Salivary cortisol was also pooled at a pen level and analysed using an Unbalanced General Linear Model design for treatment, period and day as well as interactions. Baseline salivary cortisol was used as a covariate in the analysis of salivary cortisol samples for Day 4 (Experiment One) and Day 5 (Experiment Two) at mixing and on Day 7. Differences were determined by least significant difference ($P<0.05$).

3. Outcomes

<u>Experiment One</u>

Behavioural Observations

A generalized linear model revealed that introducing the supplement block or feeding at a higher level of 4.0 kg/day resulted in significantly reduced chase behaviour ($P<0.05$, Table 6). There was a trend ($P<0.10$) for sows to spend less time engaged in foraging behaviour when offered the high level of feeding, whilst the addition of the block also appeared to reduce time spent foraging. The addition of the block and feeding at a higher level also had a significant effect on posture, with sows on both these treatment groups spending less time standing, and a greater time spent lying ($P<0.05$) than the control group.

Table 6 - Mean time (min) sows' spent engaged in behaviour and posture 1 h after feeding over the four days of observation, for sows in the control group and receiving 2.3 kg/day, sows receiving a high-feeding level (4.0 kg/day) or sows receiving a supplement block in addition to 2.3 kg feed/day.

	Treatment				
Activity	**Control**	**Block**	**High feed**	**SED**	***P* value**
Push	0.09	0.08	0.10	0.24	0.868
Chase	0.29[a]	0.08[b]	0.11[b]	0.47	0.019
Attack	0.40	0.42	0.36	0.58	0.811
Bite	0.10	0.12	0.06	0.25	0.392
Threat	0.13	0.11	0.10	0.27	0.736
Fight time (s)	13.9	15.6	16.4	5.54	0.898
Sham-chewing	0.62	0.51	0.39	0.82	0.257
Foraging	28.48[x]	25.67[xy]	25.15[y]	9.76	0.084
Agonistic behaviour	1.01	0.81	0.73	0.94	0.186
Posture					
Lying	9.13[b]	13.30[a]	13.66[a]	11.30	0.038
Sitting	0.24	0.79	0.88	1.67	0.114
Standing	50.63[a]	45.91[b]	45.26[b]	10.85	0.006

[ab]Means in a row with different superscripts differ significantly ($P<0.05$); [xy]Means in a row with different superscripts differ significantly ($P<0.10$); Control, offered 2.3 kg/d; Block, offered 2.3 kg/d and a 30 kg block; High feed, offered 4 kg/d; SED, standard error of difference of the means; Fight time, mean length of fighting bout; Agonistic behaviour, is the combined time spent in push, chase, attack, bite and threat behaviours.

Across all experimental treatments, agonistic behaviour tended not to change significantly over the four day observation period (Table 7), with only the mean length of time spent engaged in a fight significantly decreasing after the first day ($P<0.05$, Table 7). Posture showed a similar response to fighting with significantly reduced time spent standing in the days after mixing, with more time spent sitting, and in particularly lying.

Table 7 - Mean time (min) sows' spent engaged in behaviour and posture 1 h after feeding, for all treatments over the 4 days of behavioural monitoring during the 4-day observation period.

	Day					
Activity	**4**	**5**	**6**	**7**	**SED**	***P* value**
Push	0.14	0.06	0.06	0.09	0.28	0.291
Chase	0.07	0.11	0.22	0.19	0.55	0.192
Attack	0.57	0.34	0.32	0.35	0.67	0.107
Bite	0.09	0.13	0.06	0.10	0.20	0.351
Threat	0.07	0.11	0.15	0.13	0.30	0.381
Fight time (s)	9.67[a]	3.44[b]	3.38[b]	2.56[b]	6.39	<0.001
Sham-chewing	0.52	0.54	0.43	0.55	1.15	0.920
Foraging	27.23	24.80	27.02	26.67	11.57	0.578
Agonistic behaviour	0.94	0.76	0.80	0.92	1.10	0.716

	Day					
Activity	**4**	**5**	**6**	**7**	**SED**	***P* value**
Posture						
Lying	6.48^{b}	13.30^{a}	14.47^{a}	14.12^{a}	11.19	<0.001
Sitting	0.15	0.58	0.76	0.96	2.13	0.264
Standing	53.37^{a}	46.12^{b}	44.77^{b}	44.92^{b}	11.93	<0.001

^{ab}Means in a row with different superscripts differ significantly (P<0.05); SED, standard error of difference of the means; Day, days 1-3 non-experimental held in individual stalls, day 4, day of mixing and commencement of daily observations (days 5, 6 and 7); Fight time, mean length of fighting bout; Agonistic behaviour, is the combined time spent in push, chase, attack, bite and threat behaviours.

Behavioural observations of sow interaction with the supplement block were monitored and there were no aggressive interactions associated with the block or with sows around the block. Previous work conducted by CHM Alliance which established an ethogram of block interaction also lacked block associated aggression and inter-sow interaction around the block at any given time.

Salivary Cortisol and Scratch Injuries

It was found that treatment had no significant effect on salivary cortisol levels (Table 8) or fresh scratch injuries (Table 9).

Table 8 - Mean levels of salivary cortisol (µg/dl) taken on Day 1 and considered the baseline sample; Day 4, (day of mixing) and Day 7 (4 d post mixing for sows) in the control group and receiving 2.3 kg/day, sows receiving a high-feeding level (4.0 kg/day) or sows receiving a supplement block in addition to 2.3 kg feed/day.

	Treatment				
Sample	**Control**	**Block**	**High feed**	**SED**	***P* value**
Day 1	0.50	0.38	0.47	0.06	0.219
Day 4	0.46	0.86	0.40	0.21	0.106
Day 7	0.60	0.96	0.53	0.24	0.186

SED, standard error of difference of the means; Day 1 used as a covariate in the analysis of Day 4 and Day 7.

Table 9 - Mean number of fresh scratch injuries scored on Day 5, (one day after mixing) and day 7 (4 d post mixing) of sows in the control group and receiving 2.3 kg/day, sows receiving a high-feeding level (4.0 kg/day) or sows receiving a supplement block in addition to 2.3 kg feed/day.

	Treatment				
	Control	**Block**	**High feed**	**SED**	***P* value**
Day 5	6.8	10.0	8.8	3.40	0.653
Day 7	4.8	7.3	5.0	2.76	0.614

SED, standard error of difference of the means

Further analysis revealed that day tended to have a significant effect (P=0.078) on the mean number of fresh scratch injuries with the mean number of fresh scratch injuries counted decreasing from day 5 (one day after mixing) to day 7 (4 days after mixing) (Table 10).

Table 10 - Mean number of fresh scratch injuries scored on Day 5, one day after mixing and Day 7, the final experimental day across all treatments.

	Day			
	5	7	SED	*P* value
Scratch Injuries	8.56[x]	5.72[y]	1.61	0.078

[xy]Means in a row with different superscripts differ significantly (P<0.10); SED, standard error of difference of the means

The effect of period and interactions between treatment, period and day was analysed, but they failed to show any significant effect on behavioural observations, salivary cortisol or scratch injuries.

The supplemental block was weighed on the last three days of the 4-day observation period, and results revealed that the block lost an average of about 2 kg during this time (Figure 1).

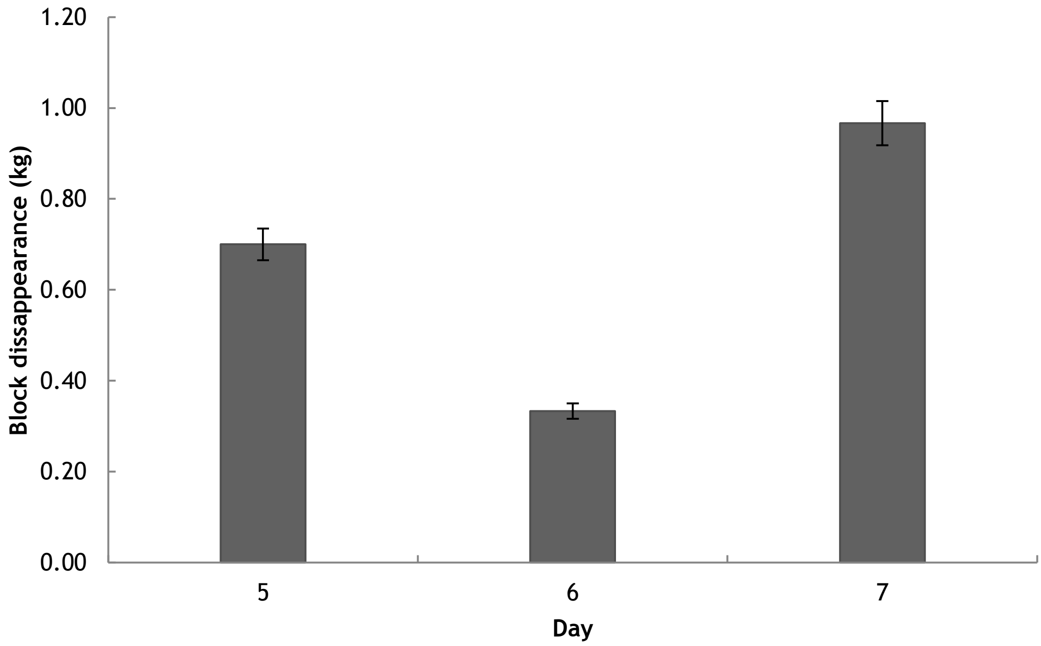

Figure 1 - Mean daily disappearance (kg) of the supplemental block during the observation period.

Experiment Two

Behavioural Observations

A generalized linear model revealed that dietary treatment had no significant effect on agonistic behaviour, foraging or postures (Table 11).

Table 11 - Mean time (min) sows' spent engaged in behaviour and posture 1 h after feeding over the three days of observation when fed a control diet or a diet containing 20 % Sugarbeet pulp (SBP), 0.2 % Magnesium oxide (MGO) and 20 % Sugarbeet pulp + 0.2 % Magnesium oxide (SBP+MGO).

	Treatment					
Activity	**Control**	**SBP**	**MGO**	**SBP+MGO**	**SED**	***P* value**
Push	0.35	0.28	0.33	0.37	0.12	0.883
Chase	0.12	0.12	0.22	0.09	0.06	0.281
Attack	0.35	0.28	0.41	0.25	0.12	0.591
Bite	0.08	0.08	0.11	0.11	0.05	0.830
Threat	0.19	0.13	0.22	0.17	0.08	0.717
Fight time (s)	2.99	2.97	1.66	5.15	1.89	0.331
Foraging	26.71	26.85	26.83	27.06	1.73	0.998
Agonistic behaviour	1.09	0.89	1.29	1.00	0.24	0.396
Posture						
Lying	15.60	13.72	12.39	14.65	2.34	0.566
Sitting	0.27	0.34	0.48	0.21	0.17	0.458
Standing	44.13	45.94	47.13	45.13	2.37	0.634

Control, fed a control diet; SBP, diet containing 20 % Sugarbeet pulp; MGO, diet containing 0.2 % Magnesium oxide; SBP+MGO, diet containing 20 % Sugarbeet pulp and 0.2 % Magnesium oxide in combination; SED, standard error of difference of the means; Fight time, mean length of fighting bout; Agonistic behaviour is the combined time spent in push, chase, attack, bite and threat behaviours.

The effect of day was analyzed using the same statistical model (Table 12). Across all dietary treatments, threat behaviour increased significantly ($P<0.05$) with the mean proportion of time (minutes) spent engaged in threat behaviour showing a significant increase on day 7 (3 days after mixing). The mean proportion of time spent engaged in chase behaviour also showed a pattern of significance ($P<0.05$) with an increase the day after mixing (day 6) before decreasing again on the final day (day 7; 3 days after mixing). There was also a trend (P=0.075) that fight time was reduced as time after mixing progressed, which is similar to the observations from Experiment 1.

Table 12 - Mean time (min) sows' spent engaged in behaviour and posture 1 h after feeding, for all treatments over the 3 days of behavioural monitoring during the 3-day observation period.

	Day				
Activity	**5**	**6**	**7**	**SED**	***P* value**
Push	0.38	0.24	0.38	0.10	0.296
Chase	0.11^{b}	0.22^{a}	0.08^{b}	0.06	0.031
Attack	0.43	0.21	0.34	0.11	0.146
Bite	0.06	0.11	0.11	0.04	0.417
Threat	0.08^{b}	0.10^{b}	0.35^{a}	0.07	<0.001
Fight time (s)	5.34	1.69	2.55	1.64	0.075
Foraging	26.78	26.56	27.25	1.50	0.896

	Day				
Activity	**5**	**6**	**7**	**SED**	***P* value**
Agonistic behaviour	1.06	0.90	1.25	0.21	0.221
Posture					
Lying	13.66	15.17	13.44	2.03	0.652
Sitting	0.19	0.45	0.35	0.15	0.242
Standing	46.15	44.39	46.21	2.05	0.604

[ab]Means in a row with different superscripts differ significantly (P<0.05); SED, standard error of difference of the means; Day, days 1-4 non-experimental held in individual stalls, day 5, day of mixing and commencement of daily observations (days 6 and 7); Fight time, mean length of fighting bout; Agonistic behaviour, is the combined time spent in push, chase, attack, bite and threat behaviours.

The effect of period and the interactions between treatment, period and day was analysed, and again showing no significant effect on behavioural observations.

Salivary Cortisol and Scratch Injuries

It was found that dietary treatment had no significant effect on salivary cortisol levels (Table 13) or fresh scratch injuries (Table 14).

Table 13 - Mean levels of salivary cortisol (µg/dl) taken on Day 1 and considered the baseline sample; Day 5, (day of mixing) and Day 7 (3 d post mixing for sows) in the control group when fed a control diet or a diet containing 20 % Sugarbeet pulp (SBP), 0.2 % Magnesium oxide (MGO) and 20 % Sugarbeet pulp + 0.2 % Magnesium oxide (SBP+MGO).

			Treatment			
Sample	**Control**	**SBP**	**MGO**	**SBP+MGO**	**SED**	***P* value**
Day 1	0.21	0.21	0.22	0.26	0.39	0.821
Day 5	0.42	0.49	0.42	0.39	0.79	0.839
Day 7	0.99	0.78	0.77	0.74	0.23	0.956

Day, days 1-4 non-experimental held in individual stalls, day 5, day of mixing and commencement of daily observations (days 6 and 7); Control, fed a control diet; SBP, diet containing 20 % Sugarbeet pulp; MGO, diet containing 0.2 % Magnesium oxide; SBP+MGO, diet containing 20 % Sugarbeet pulp and 0.2 % Magnesium oxide in combination; SED, standard error of difference of the means. Day 1 used as a covariate in the analysis of Day 5 and Day 7.

Table 14 - Mean number of fresh scratch injuries scored on Day 6, (one day after mixing) and day 7 (3 d post mixing) of sows in the control group when fed a control diet or a diet containing 20 % Sugarbeet pulp (SBP), 0.2 % Magnesium oxide (MGO) and 20 % Sugarbeet pulp + 0.2 % Magnesium oxide (SBP+MGO).

			Treatment			
	Control	**SBP**	**MGO**	**SBP+MGO**	**SED**	***P* value**
Day 6	16.2	22.5	18.0	22.7	7.91	0.797
Day 7	7.5	5.8	5.3	5.0	2.50	0.758

Day, days 1-4 non-experimental held in individual stalls, day 5, day of mixing and commencement of daily observations (days 6 and 7); Control, fed a control diet; SBP, diet containing 20 % Sugarbeet pulp; MGO, diet containing 0.2 % Magnesium oxide; SBP+MGO, diet containing 20 % Sugarbeet pulp and 0.2 % Magnesium oxide in combination; SED, standard error of difference of the means.

The effect of day on salivary cortisol was analysed using the same statistical model revealing a significant increase (*P*<0.05*)* of salivary cortisol levels overtime from Day 1 to Day 7 (Table 15).

Table15 - Mean levels of salivary cortisol (µg/dl) taken on Day 1 and considered the baseline sample; Day 5, (day of mixing) and Day 7 (3 d post mixing for sows) for all treatments over the 3 days of behavioural monitoring during the 3-day observation period

	Day				
	1	5	7	SED	*P* value
Salivary cortisol	0.23[c]	0.43[b]	0.81[a]	0.68	<0.001

[ab]Means in a row with different superscripts differ significantly (P<0.05); SED, standard error of difference of the means; Day, days 1-4 non-experimental held in individual stalls, day 5, day of mixing and commencement of daily observations (days 6 and 7).

The effect of day was then analysed on scratch injuries, and it was found that day tended to have a significant effect (*P*<0.001) on the mean number of fresh scratch injuries with fresh scratch injuries counted decreasing from day 6 (day after mixing) to day 7 (2 days after mixing) (Table 16). These observations are similar to those in Experiment 1 where, again, fresh scratch injuries tended to fall during the days after mixing.

Table 16 - Mean number of fresh scratch injuries scored on Day 6, one day after mixing and Day 7, the final experimental day across all treatments.

	Day			
	6	7	SED	*P* value
Scratch Injuries	19.8[a]	5.9[b]	2.88	<0.001

[ab]Means in a row with different superscripts differ significantly (P<0.05); SED, standard error of difference of the means.

The effect of period and the interactions between treatment, period and day was analysed, showing no significant effect on salivary cortisol or scratch injuries.

4. Discussion

The recent transition from individual housing during early gestation to group-housing has seen many different gestation housing systems adopted. This transition has seen mixing sows, which may be unfamiliar to each other, become common practice. This allows opportunity for fighting to establish a social ranking. Fighting may result in injury or lameness, as well as having the potential to cause repetitive fear and anxiety in sows. The onset of fighting is initially due to the establishment of a social rank with ongoing aggression occurring predominantly because of competition for access to a limited resource (Spoolder *et al.*, 2009), primarily associated with food. Although this interaction can be frequent, it is often short in duration.

It was found in Experiment One and Two that the display of aggression associated with feeding was constant across treatment groups, which corresponds with what was found by Arey and Edwards (1998), in that aggression during floor-feeding has been seen to remain constant for up to 56 days after mixing. However, there was a significant effect of treatment on the display of chase behaviour in Experiment One, as it appeared to be positively affected by the presence of a block supplement or a higher feeding level. Sows also tended to spend less time foraging and more time lying, 1 h after feeding, in the pens fitted with a block supplement or fed at a higher level compared to that of the control group. Furthermore, during this time, we observed that those sows allocated to the control group would often consume all feed in a very short period while those sows allocated to pens fitted with a supplement block or offered a higher feeding level would often have feed still present at feeding time the next morning. Those sows offered a higher feeding level may have consumed close to maximum gut fill in that single feed event, whilst it remains uncertain the effect the supplement block may have had to decrease the amount of time spent foraging during this time, given consumption of the block was limited.

Hierarchy positions in groups of sows are settled relatively quickly (Arey and Edwards, 1998) as was witnessed in both Experiments One and Two, with the mean time sows spent fighting greatly reduced after the first 24 hours after mixing. Similarly Barnett *et al.* (1992) and Pritchard *(*1996) reported that the total number of recorded aggressive interactions fall by the second day after mixing to an average level which was maintained over the following days We found that fighting time was dramatically reduced from a mean of 9.67 and 5.34 seconds on the day of mixing in Experiments 1 and 2 to just 3.44 and 1.69 seconds, respectively, the day after mixing., Fighting time remained at less than 3.4 seconds for the remainder of the observation period in both Experiments.

During the observational period in Experiment Two, chase and threat behaviours appeared to change over the days after mixing. Chase behaviour appeared to increase the day after mixing, before falling for the subsequent day. Threat behaviour illustrated a pattern of increasing over time, being displayed least frequently on the day of mixing. These patterns of displayed behavioural changes in Experiment 2 may indicate a change in chosen aggressive behaviours as hierarchal positions are established within a group of previously unfamiliar sows. We found that as fighting time, considered a more aggressive behaviour, was dramatically reduced in the immediate days after mixing, threat behaviour increased.

Although not evident in Experiment One or Two, lesions or scratch injuries have previously been found to correlate with the number of aggressive interactions (Barnett *et al.* 1992). Fresh scratch injuries were higher the day after mixing and decreased during the subsequent days in a similar pattern to the length of fight time in both Experiments. However, most of the aggressive behaviours associated with feeding were not affected by treatment and did not appear to correlate with scratch injuries.

Regrouped weaned sows have been found to show elevated cortisol levels on the day of grouping (Pederson *et al.,* 1993). However, individual samples are often variable and inadequately measure acute responses which may occur less, after initial fighting at mixing. In Experiment One and Two, mean levels of salivary cortisol were not affected by experimental treatment, however the effect of day did reveal an increase in salivary cortisol levels overtime in Experiment Two. These results tend to contradict what would be expected, as the level of fighting and prevalence of fresh scratch injuries decreased overtime.

5. Application of Research

Either providing sows with an increased feeding level of 4.0 kg/day or the use of a supplement block would appear to be useful to decrease foraging behaviour at feeding time which in turn decreases aggressive chase behaviour. Although most aggressive behaviours associated with feeding time and mixing unfamiliar sows were not affected, the supply of the supplement block may provide enrichment for sows in group housing.

It has been hypothesized that bulky fibre types such as sugarbeet pulp increase satiety and thereby decrease aggression in group-housed sows (Danielsen *et al.* 2001). In the present study, behaviour remained unchanged by the dietary inclusion of either sugar beet pulp or magnesium oxide at commercially accepted levels in gestation sow diets just prior to mixing and for the short period of 3-4 days after mixing sows. The feeding of products such as sugar beet pulp may only be effective in decreasing aggressive behavior in group housed sows if included in the diet for significantly longer periods.

6. Conclusion

The provision of either a supplement block or a higher feeding level of 4.0 kg/day in Experiment One had a desirable effect on aggressive chase behaviour seen at the time of feeding. It also appeared to increase lying behaviour and decrease the amount of time spent foraging immediately after feeding. The lack of effect of diets aimed to induce satiety on aggressive behaviour, studied in Experiment Two, was unexpected given their positive effects in literature. However, the feeding of these type of "satiety" products may only be effective if they are included in the diet for longer periods than the several days that were examined in Experiment 2. Although stress levels (as measured by pooled cortisol) in Experiment Two appeared to rise at the time of mixing, and continue to do so 2 days after, the level of fighting and fresh scratch injuries in the two experiments was most frequent only on the day of mixing. Both fighting and fresh scratch injuries often significantly decreased within a couple of the days after mixing, providing further evidence that the sow quickly adapts to group housing.

7. Limitations/Risks

The use of a supplement block did appear to decrease aggressive chasing behaviour associated with feeding. The block used in this study was placed on the floor and not fixed to the pen infrastructure. By fixing the block with a chain to the walls, if desired, the supplement block may be used to a greater extent by the sows in the group housing environment. As seen in previous work conducted internally by CHM Alliance, the inclusion of a play element increases sow interest.

8. Recommendations

As a result of the outcomes in this study the following recommendations have been made:

- Use of a supplement block and the spread of increased feed over a larger area, decreases chasing behaviour at feeding time and increased lying time.
- Inclusion of sugar beet pulp at 20% of the gestation diet to induce satiation and offered just prior to, and after mixing failed to affect aggressive behavior of mixed sows.
- The addition of 0.2 % Magnesium oxide into a sow diet which was aimed to stabilize insulin levels, also did not significantly affect aggressive behaviour in newly mixed sows
- Fighting time associated with mixing unfamiliar sows is highest on the first day of mixing and greatly decreases by the following day. Thus it is suggested that strategies to reduce fighting may need only be considered for the very early stages of mixing.
- The use of a supplemental block as enrichment in group housing may include the block being fitted with a chain or other element if it is desirable to initiate play behaviour.
- It is recommended that the supplemental block be examined for longer term use during gestation to possibly improve satiation and welfare of sows in group housing systems.

9. References

Arey, D. and Edwards, S. (1998) Factors influencing aggression between sows after mixing and the consequences for welfare and production. *Livestock Production Science.* **56:** 61-70.

Barbagallo, M., Dominguez, L., Galioto, A. Ferlisi, A., Cani, C., Malfa, L., Pineo, A., Burardo, A. and Paolisso, G. (2003) Role of magnesium in insulin action, diabetes and cardio-metabolic syndrome X. *Molecular Aspects of Medicine.* **24:** 39-52.

Barnett, J., Hemsworth, P., Cronin, G., Newman, E., McCallum, T. and Chilton, D. (1992) Effects of pen size, partial stalls and method of feeding on welfare-related behavioural and physiological responses of group-housed pigs. *Applied Animal Behavioural Science.* **34:** 207-220

Beattie, V., Walker, N. and Sneddon, I. (1995) Effects of environmental enrichment on behaviour and productivity of growing pigs. *Animal Welfare* **4:** 207-220

Bergeron, R., Boldue, J., Ramonet, Y., Meunier-Salaün., M. and Robert, S. (2000) Feeding motivation and stereotypies in pregnant sows fed increasing levels of fibre and/or food. *Applied Animal Behaviour Science* **70**: 27-40

Bo, S. and Pisu, E. (2008) Role of dietary magnesium in cardiovascular disease prevention, insulin sensitivity and diabetes. *Current Opinion in Lipidology.* **19:** 50-56.

Danielsen, V. and Vestergaard, E. (2001) Dietary fibre for pregnant sows: effect on performance and behaviour. *Animal Feed Science and Technology* **90**: 71-80.

de Leeuw, J., Bolhuis, J., Bosch, G. and Gerrits, W. (2008) Effects of dietary fibre on behaviour and satiety in pigs. *Proceedings of the Nutrition Society* **69**: 334-342

Durrell, J., Sneddon, I. and Beattie, V. (1997) Effects of enrichment and floor type on behaviour of cubicle loose-housed dry sows. *Animal Welfare* **6:** 297-308

Jones, R., Carmicheal, N. and Rayner, E. (2000) Pecking preferences and pre-depositions in domestic chicks:implications for the development of environmental enrichment devices'. *Applied Animal Behaviour Science* **69:**291-312

Meunier-Salaun, M.C., Edwards, S.A and Robert, S. (2001) Effect of dietary fibre on the behaviour and health of the restricted fed sow. *Animal Feed Science and Technology* **90:** 53-69

Pederson, L., Rojkittikhun, T., Einarsson, S. and Edqvist, L. (1993) Postweaning grouped sows: effects of aggression on hormonal patterns and oestrus behaviour. *Applied Animal Behavioural Science*. **38:** 25-39.

Pritchard, V. (1996) Oestrous and mating behaviour in group housed sows and the effect of social dominance. MSc Thesis. University of Aberdeen. UK.

Schaefer, A., Salomons, M., Tong, A., Sather, A. and Lepage, P. (1990) The effect of environmental enrichment on aggression in newly weaned pigs. *Applied Animal Behaviour Science* **27:** 41-52