AFBI Hillsborough

Feed restriction prior to slaughter

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1. EXECUTIVE SUMMARY

Feed restriction on the farm prior to slaughter is a relatively easy way to reduce contamination of carcasses from bacteria of punctured stomachs at the abattoir. In addition it may save small amount of feed, reduce mortality in transport, improve bleeding out and reduce the amount of waste to be disposed of at the abattoir. However, prolonged feed restriction may also result in loss of carcass weight and poorer meat quality e.g. DFD. Furthermore, not all pigs in a pen are ready for slaughter together and the effect of repeated feed restriction is unknown. This experiment aimed to determine the effects of several feed restriction periods prior to slaughter on performance, meat quality and feeding behaviour of pigs. 540 crossbred pigs were allocated to 3 treatments (no feed restriction, 12 hr feed restriction, 20 hr feed restriction prior to slaughter). Performance, behaviour and meat quality of the pigs were monitored during pre, during and post feed restriction.

Feed restriction for 12 hours prior to slaughter did not adversely affect performance, carcass weight, meat quality or welfare in the present study. This is beneficial to farmers by saving approximately 1.5 kg feed/pig, processors by reducing waste and consumers by improving food safety. Careful management of the feeder could save feed costs of approximately 25 p/pig. Fasting for 20 hours reduced carcass weight by 1 kg which was not statistically significant but could result in losses of 30-70 p/pig. The negative effects on meat quality of repeated feed restrictions resulted from slower growth rates rather than feed restriction *per se*. Improving performance and meat quality of slow growing pigs is an area which warrants further research.

2. INTRODUCTION

It is vitally important in pig production that a safe, as well as nutritious, product is supplied to the consumer. Recent cases of bacterial contamination of foodstuffs has highlighted the need for an integrated approach to minimise the effects of food borne pathogens. If the stomach of the animal is punctured during the evisceration process at the slaughter house, carcasses can become contaminated with bacteria from the gastrointestinal tract. The risk of carcass contamination is considerably reduced if the pigs stomach is empty at the time of slaughter (Miller *et al*., 1997). Feed restriction on the farm prior to slaughter is a relatively easy way to achieve this and has the added advantages of saving a small amount of feed, reducing mortality during transport, improving bleed out and reducing the amount of waste to be disposed of at the abattoir (Miller *et al*., 1997; Eikelenbloom *et al*., 1991). On the other hand, if the period of feed restriction is prolonged, economically important live weight and carcass losses may occur (Murray and Jones, 1994). Enforced feed restriction is a potent stressor in other species (Freeman *et al*., 1980) and may constitute a welfare issue and in addition if muscle glycogen is depleted by fasting before slaughter, the amount of lactic acid formed after death is reduced and the ultimate pH of the meat is higher than normal. This leads to the formation of dark, firm, dry (DFD) meat (Warriss, 1998) of poor keeping quality. Other meat quality aspects such as colour and tenderness may be adversely affected (Warriss, 1982; Warriss and Brown, 1983; Eikelenbloom *et al*., 1991).

When pigs are slaughtered on a fixed weight, rather than fixed age basis, some pigs will reach that slaughter weight more slowly. This means that a group of pigs will be slaughtered over a period of time as pigs attain slaughter weight. Unless a feeding system which is capable of recognising individual pigs is available, the whole group, regardless of slaughter weight must be restricted in a group housing situation. Therefore, some pigs may experience several periods of feed restriction before slaughter. This experiment was conducted to determine the effects of feed restriction prior to slaughter on performance, meat quality and feeding behaviour of pigs.

3. MATERIALS AND METHODS

3.1 Treatments

There were three experimental treatments (Table 1). Treatment 1 was the control where pigs had *ad libitum* access to feed up to the point of loading on the day of slaughter (Tuesday 8.00 a.m.). Treatment 2 involved closing off the feeders at 8.00 p.m. on the day prior to slaughter (Monday) which resulted in a 12 hour fast. Feeders on the third treatment, Treatment 3, were closed off at 12.00 noon on the day prior to slaughter (20 hour fast). Once pigs were removed from the pen for transport to the abattoir, feed was immediately made available to the remaining pigs in the pen. All pigs had unlimited access to water throughout the experiment.

3.2 Pigs/housing/feeding regime

Five hundred and forty crossbred pigs, were allocated to a three-treatment, randomised block experiment. There were fifty-four pigs per replicate and the experiment was replicated ten times providing 180 pigs per treatment. Pigs were housed in groups of 18 in finishing accommodation in pens with fully slatted floors (0.70 m^2 per pig). Feed was supplied *ad libitum* via one head to head shelf feeder per pen. Water was available from two nipple drinkers one in each side of the feeder. The week before the first pig was expected to attain slaughter weight was designated “week 0”. All animals were weighed each week from week 0 at 8.00 a.m. on the day before slaughter (Mondays) and were selected individually for slaughter when boars and gilts reached 105 and 100 kg respectively. Slaughter pigs were also weighed immediately prior to transport to the abattoir (8.00 a.m. Tuesday) to determine weight loss during fasting.

3.3 Assessments

3.3.1 Production

Normal production parameters, feed intake, growth rate, FCR, KO%, backfat depth at the P_2 position (thickness of subcutaneous fat above *m. Longissimus* 65 mm from the dorsal midline at the level of the last thoracic vertebra) were taken.

3.3.2 Meat quality

Sample joints from approximately 250 pigs (3 chops from the “rib back” region of the carcass, left *L Dorsi*) were collected from the abattoir on the day after slaughter. These sample joints were then subjected to a number of meat quality assessments as described by Beattie *et al*. (1999). Ultimate pH and colour (L*, a*, b* Chroma Hue) of the *M. Longissimus* were measured as these parameters are indicators of pre-slaughter stress.

Table 1 Experimental treatments and schedule of behaviour recordings

	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Treatment 1 Control (0 h fast)			Weigh pigs 8.00 a.m.	Weigh and load slaughter pigs 8.00 a.m.			
Treatment 2 8.00 p.m. (12 h fast)	Record behaviour	Record behaviour	Weigh pigs 8.00 a.m. Feeder off 8.00 p.m.	Weigh and load slaughter pigs 8.00 a.m., feeders back on record behaviour	Record behaviour	Record behaviour	
Treatment 3 12.00 noon (20 h fast)	Record behaviour	Record behaviour	Weigh pigs 8.00 a.m. Feeder off 12.00 noon	Weigh and load slaughter pigs 8.00 a.m., feeders back on record behaviour	Record behaviour	Record behaviour	

A high ultimate pH is associated with dark, firm, dry (DFD) meat while a rapid decrease in pH post slaughter and a low ultimate pH is associated with pale, soft, exudative (PSE) meat. Water holding capacity (drip and cooking loss) and tenderness (Warner Bratzler shear force) are important technological measures of meat quality and are good indicators of consumer acceptability.

3.3.3 Behaviour

Each pig in the pen was identified by a number sprayed on its back. Feeding behaviour was recorded using time-lapse video recording equipment (2 frames per second) placed above the feeder for 48 hours prior to weighing, i.e. Saturday mornings. When any pigs were removed from the pen for slaughter, feeding behaviour was recorded for 96 hours after the feeders were closed off. This allowed a comparison of feeding behaviour before feeders were turned off and after feeders were turned back on for pigs which were fasted for 12 hours or 20 hours. The frequency and duration of visits to the feeder were calculated for each individual pig.

4. RESULTS AND DISCUSSION

4.1 Production performance

Final weights based on pre-fast (Monday) weighings were not significantly different for pigs on the three treatments but final weight from Tuesday weighings was significantly lower (P<0.01) for pigs on Treatment 3 (20 hour fast) (Table 2).

Table 2 The effect of feed restriction prior to slaughter on production performance

	Treatment				
	1	2	3		
	Control (0 h fast)	**8.00 pm (12 h fast)**	**12.00 noon (20 h fast)**	**SEM**	**P**
35-93 kg					
Start weight (kg)	35.0	35.1	35.1	0.04	NS
ADG (g/day)	933	940	944	13.9	NS
Week 0 weight (kg)[1]	92.6	93.1	93.6	0.90	NS
93-105 kg					
Final weight Monday (kg)[2]	105.6	105.5	105.5	0.51	NS
Final weight Tuesday (kg)[3]	105.8^{b}	104.2^{b}	102.0^{a}	0.62	**
Weight change (kg)[4]	+0.3^{c}	-1.3^{b}	-3.5^{a}	0.22	***
Feed intake (kg/day)	2.66	2.74	2.71	0.06	NS
ADG (g/day)	1012	1024	950	53.2	NS
FCR (kg/kg)	2.80	3.05	3.01	0.150	NS
Cold weight (kg)	79.8	79.8	78.8	0.55	NS
KO %	75.5^{a}	76.6^{b}	77.3^{b}	0.21	***
P_2 (mm)	11.9	11.8	11.6	0.17	NS
Lean % Ulster Probe	57.6	57.7	57.8	0.17	NS

1 Pig weight at 8.00 a.m. on the Monday one week before the first pig was expected to reach slaughter weight
2 Pig weight at 8.00 a.m. on the day before slaughter
3 Pig weight at 8.00 a.m. immediately prior to transport to the abattoir
4 The difference between Monday weight and Tuesday weight

Daily feed intake, daily liveweight gain and FCR were similar for all three treatments. Pigs on treatments 2 and 3 (12 and 20 hour fast respectively) had a higher KO% than pigs on the control treatment (*ad libitum* feeding up to time of transport) (P<0.001). Backfat depth at the P_2 position was not significantly affected by feed restriction, the mean value being 11.8 mm. Average daily gains of 939 g/day from 35-93 kg live weight and 995 g/day from 93-105 kg live weight were in line with previous studies at this Institute (Weatherup *et al*., 1998).

Significant losses of live weight but no significant losses in cold weight are also in line with published studies where liveweight losses began immediately after the onset of fasting but carcass weight losses did not begin for 9-18 hours after fasting (Warriss and Brown, 1983). Liveweight losses are mainly due to excretion while carcass weight losses may be due to a combination of reduction in blood volume, fat mobilisation, carbohydrate metabolism and water loss (Bowland and Standish, 1966; Warriss and Brown, 1983).

Table 3 A comparison of fast duration and weight losses in various published studies

Live weight (kg)	Duration of fast (h)	Carcass weight loss (kg)	Author
62	18	0.7	Warriss and Brown (1983)
	24	0.9	
	48	2.2	
90	24	0.9	Bowland and Standish (1966)
	48	2.8	
97	70	2.9	Davidson *et al.* (1968)
100	24	1.1	Saffle and Cole (1960)
	48	1.5	
105	12	0	present study
	20	1.0	

4.2 Meat quality

Although the differences in ultimate pH (pHu) and cooking loss were significant (P<0.01 and P<0.001 respectively), the effects were small, all values lay in the normal acceptable range and no cases of DFD (Dark, Firm, Dry) or PSE (Pale, Soft, Exudative) meat were observed (Table 4). All other meat quality parameters were not significantly different for the three experimental treatments in agreement with De Smet *et al.* (1996).

When data were analysed for the effects of number of feed restrictions, it was observed that drip and cooking losses increased significantly with number of feed restrictions (Table 5). However, the effects of growth rate and number of restrictions are very closely related as animals which grew more slowly were restricted more often. To tease out these effects, meat quality data from control pigs slaughtered over a period of 3 weeks but never having experienced feed restriction were analysed.

Table 4 The effect of feed restriction prior to slaughter on meat quality

	Treatment			SEM	P
	Control (0 h fast)	8.00 pm (12 h fast)	12.00 noon (20 h fast)		
pHu (Homogenate)	5.51[a]	5.49[a]	5.54[b]	0.011	**
% Cooking loss	23.6[a]	25.2[b]	24.0[a]	0.37	**
% Drip loss	5.21	5.43	4.99	0.210	NS
Shear (kg/cm^2)	3.35	3.36	3.45	0.075	NS
L*	56.2	55.5	55.8	0.36	NS
a*	4.38	4.40	4.41	0.139	NS
b*	9.09	9.25	9.36	0.132	NS
Chroma	10.13	10.30	10.39	0.160	NS
Hue	64.4	65.0	65.1	0.60	NS

Table 5 The effect of number of feed restrictions on growth performance and meat quality (data for pigs fasted for 12 and 20 hours).

	Number of feed restrictions			sed	Sig
	1	2	3		
Growth performance					
ADG g/day (35-93 kg)	994[b]	901[a]	888[a]	22.4	***
ADG g/day (93-105 kg)	1131[b]	922[a]	874[a]	73.9	***
P_2 (mm)	12	11	12	0.5	NS
Meat quality					
pHu (Hom)	5.53	5.50	5.47	0.022	NS
% Cooking loss	23.9[a]	23.8[a]	28.1[b]	0.72	***
% Drip loss	4.71[a]	5.59[b]	6.57[c]	0.411	***
Shear (kg/cm^2)	3.38	3.40	3.43	0.153	NS
L*	55.2	56.3	55.3	0.73	NS
a*	4.35	4.07	4.77	0.269	NS
b*	9.36	8.92	9.59	0.268	NS
Chroma	10.37	9.83	10.76	0.320	NS
Hue	65.4	65.7	64.1	1.17	NS

A similar pattern was seen in that drip and cooking losses were higher for the slower growing pigs, independent of feed restriction (Table 6). Drip and cooking losses are two important measures of moisture holding capacity which impact strongly on eating quality. Muscles are composed of bundles of thick and thin filaments ordered in a regular array. The moisture content of muscle is approximately 75% but only a small proportion is chemically bound, the rest is present in spaces between the thick and thin filaments. Water holding capacity is significantly reduced post mortem due to decreases in muscle pH and shrinkage and contraction of the muscle fibres causing water to be expelled (den Hertog-Meischke *et al*., 1997). "Drip" emerges from the cut surface of meat and is unsightly and represents a major loss of nutrients as it contains a high concentration of proteins, amino acids, peptides and B vitamins. The shelf life of the meat and the safety of the consumer may also be jeopardised as drip is an excellent substrate for the growth of micro-organisms (den Hertog-Meischke *et al*., 1997).

Table 6 The effect of slaughter week on meat quality and growth performance of control pigs

	Slaughter week				
	1	2	3	sed	Sig
Performance					
ADG g/day (35-93 kg)	1041[b]	877[a]	874[a]	32.3	***
ADG g/day (93-105 kg)	1082	909	942	243.0	NS
P_2 (mm)	12	11	12	1.0	NS
Meat quality					
pHu	5.52	5.51	5.48	0.051	NS
% Cooking loss	21.8[a]	24.4[a]	28.4[b]	1.62	***
% Drip loss	4.9	5.9	6.5	0.95	NS
Shear (kg/cm^2)	3.3	3.8	3.5	0.28	NS
L*	56.2	56.4	57.2	1.88	NS
a*	4.3	3.8	4.8	0.55	NS
b*	8.9	8.7	9.3	0.56	NS
Chroma	9.9	9.5	10.6	0.65	NS
Hue	64.5	66.3	62.9	2.52	NS

Cooking losses are normally higher than drip losses although the exact amount depends on the cooking procedure used. Cooking losses also consist of non-aqueous fluid since fat is melted and the structures retaining it are destroyed (Lawrie, 1974). This measure of water holding capacity is particularly important as it is directly correlated with loss of juiciness to the palate.

Statistical analysis of data from all three treatments confirmed that regressions of growth rate were significant for cooking loss ($P<0.001$), drip loss ($P<0.001$), shear force ($P<0.01$), a* ($P<0.05$), b* ($P<0.05$) and chroma ($P<0.05$). However, although statistically significant, the relationships were weak, indicating that other factors than growth rate also contributed to the poorer meat quality of slower growing pigs. These other factors cannot be identified conclusively from this study but may be related to their muscle type, muscle metabolic profile, feed intake or growth hormone secretion (Staun, 1972; Essén-Gustavsson and Fjelkner-Modig, 1985; Lefaucher *et al*., 1992). In addition, there may be some stress associated with the loss of penmates when pigs are removed each week.

An obvious question to ask is whether anything can be done to improve the meat quality of these slow growing pigs. An MLC study (Blanchard *et al*., 1998) has shown that it is possible to affect tenderness of meat by feeding a high energy/low protein diet for two weeks prior to slaughter. Vitamin E supplementation of a diet for steers significantly reduced drip loss by stabilising cell integrity (Mitsumoto *et al*., 1995) and is also beneficial for pork quality (Wood, 1984; Monaghan *et al*., 1990). It appears that it is possible to manipulate meat quality, even over a short period of time and this is an area which warrants further research.

4.3 Behaviour

Pigs which were restricted for 20 hours (Treatment 2) spent significantly more time at the feeder post fasting. This was particularly marked during the first 2-3 hours when access to feed was restored (Figure 1). The feeding pattern of pigs which were restricted for 12 hours was very similar to that observed before feed restriction. This is supported by the results of previous studies at this Institute where Walker (1991) demonstrated that with 10 pigs per feeding place feeder occupation was minimal from 6.00 p.m. to 6.00 a.m. and therefore the imposed "fast" in Treatment 2 (8.00 pm) may have only affected a few subordinate pigs which are more likely to feed during the night.

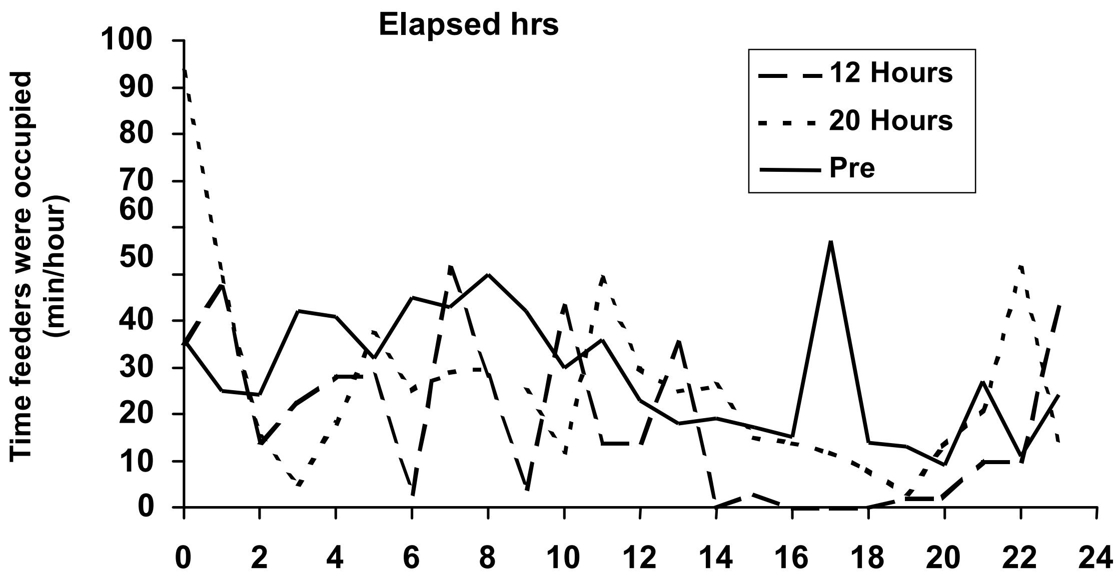

Figure 1 Time feeders were occupied pre- and post-feeders off

In contrast, feeder occupancy reached a peak of almost 100% from 12.00 noon to 6.00 p.m. and therefore Treatment 3 could represent a truer fast. Clearly there will be some conflict of interests in that pigs fasted for 20 hours are hungry and therefore, it could be argued that their welfare is compromised. On the other hand, fasting for 12 hours removes 1.3 kg gut fill/pig which may improve welfare during transport (Warriss, 1998). The likely saving in feed costs of a 12-hour fast would be in the order of 20-25 p/pig based on finisher feed costing £150-180/tonne. Pigs which were fasted for 20 hours had 1 kg less carcass weight, worth 75 p at time of writing, which overrides the savings in feed costs of 45-54 p/pig. It appears that a 12-hour fast represents a good compromise in terms of welfare and has some economic benefit. For the processor, an economic disadvantage of fasting pigs is reduced liver weight. Warriss and Brown (1983) estimated that the rate of liver weight loss during the first 24 hours of fasting was 0.7%/hour. For pigs slaughtered at 105 kg live weight and fasted for 12 hours, this is equivalent to a total of approximately 150 g of liver weight loss.

5. CONCLUSIONS

Feed restriction for 12 hours prior to slaughter did not adversely affect performance, carcass weight, meat quality or welfare in the present study. This is beneficial to farmers by saving approximately 1.5 kg feed/pig, processors by reducing waste and consumers by improving food safety. Careful management of the feeder could save feed costs of approximately 25 p/pig. Fasting for 20 hours reduced carcass weight by 1 kg which was not statistically significant but could result in losses of 30-70 p/pig. The negative effects on meat quality of repeated feed restrictions resulted from slower growth rates rather than feed restriction *per se*. Improving performance and meat quality of slow growing pigs is an area which warrants further research.

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