Enhancement of pigmeat quality by altering pre-slaughter management

Authors

P.G. Lawlor, Pig Production Department, Moorepark, Fermoy, Co. Cork

P.B. Lynch, Pig Production Department, Moorepark, Fermoy, Co. Cork

J. Mullane, Pig Production Department, Moorepark, Fermoy, Co. Cork

J.P. Kerry, Department of Food Technology, University College, Cork

S.A. Hogan, Department of Food Technology, University College, Cork

P. Allen, The National Food Centre, Dunsinea, Ashtown, Dublin 15.

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1. Summary

The studies presented in this report were conducted to investigate the effect of breed, slaughter weight, castration of male pigs and strategic feeding strategies on the performance of pigs to slaughter and on their carcass quality.

The effect of breed, gender and feeding regimen on the performance of pigs and their carcass quality was examined in the first study (Section 3). From weaning to slaughter Landrace-sired pigs grew at a similar rate but had a better feed conversion efficiency compared with Duroc-sired pigs. Landrace-sired pigs also had a higher carcass lean and greater muscle depth than Duroc-sired pigs. Entire male pigs grew more efficiently, had lower lean content in their carcasses and had a reduced kill out yield when compared with gilts. The eye muscle depth was greater for gilts than entire males.

Diluting the diet with grass-meal (GM) reduced growth rate, caused a deterioration in feed conversion efficiency, reduced back fat thickness, reduced eye muscle thickness and reduced kill out yield compared to the control feeding regimen of a cereal based diet. Compensatory growth was observed during a re-alimentation period following a period of diet dilution with grass-meal. However, where it did occur, in most cases it was only partial. Adding 5% rapeseed oil instead of lard to the finisher diet increased nitrogen utilization efficiency and phosphorous utilization efficiency.

The effect of gender (boar, castrate, gilt) and slaughter weight (80 to 120kg) on pig performance, carcass quality, meat quality, and nitrogen excretion was investigated in the second study (Section 4). Boars grew faster than gilts and more efficiently than castrates or gilts. Castrates had a higher kill out yield than boars. Nitrogen excretion from castrates was similar to gilts which were both higher than that from boars. The processing value of carcasses from castrates may be higher than that of boars and gilts. In particular castrates had heavier loins and bellies than either boars or gilts. Carcasses from castrates and gilts had a higher temperature (recorded 24 hours post slaughter) than boars. However, pH_{24} was not affected by gender. The intramuscular fat content of the *l. dorsi* in castrates was higher than that of boars or gilts, however at 1.65% this was well below the level (2.0%) above which any noticeable sensory attributes might be detected.

Feed intake increased with increasing slaughter weight and feed conversion efficiency deteriorated. N excretion also increased with each increment in weight. Carcass lean content increased up to 90kg live

weight then reached a plateau and declined after 110kg live weight. Heavier carcasses yielded more product for approximately the same slaughtering cost and the associated larger muscles could make it easier to use seam butchery techniques that result in lean, well-trimmed, attractive cuts and joints. The pH_{45} and pH_{24} were reduced with increasing slaughter weight and drip loss increased. Heavier pigs may be more prone to the development of PSE than lighter pigs as their carcass temperature remains higher for longer than that of lighter pigs.

2. Introduction

The average carcass weight of pigs slaughtered in Ireland is c. 70 kg. This is light by European and international standards and only in the UK are carcass weights as low. Carcass weight has remained light in Ireland and the UK because both countries use entire male pigs and boar taint problems may arise from increasing slaughter weight. Considerable savings in per unit processing costs are associated with increasing slaughter weight and because of this processors are anxious that the possibility of increasing slaughter weight be examined. Increased carcass weight would also result in larger joints (preferred by some sectors of the processing and catering industries), which are currently being supplied to a large extent through imports (Bord Bia, 1999).

Among the main recommendations in the 'Agri Food 2010' Report was that "Ireland's reputation as a quality food producer is essential for the future of the agri-food sector" (DAFRD, 2000). Irish pork and pigmeat products are frequently criticised for having become dry and tough. This reduction in eating quality is associated with increases in the leanness of genotypes now used. Increasing slaughter weights could improve the eating quality of pork by increasing the levels of intramuscular fat. Modern very lean strains of pigs may show a lesser deterioration in performance at farm level (especially feed conversion efficiency), than heretofore, when finished at higher slaughter weights.

Castration (physical or by immunisation) may allow males to be taken to increased slaughter weights without the risk of boar taint. Castration of male pigs ceased at a time when pigs had a tendency to lay down large levels of fat. Hanrahan (1979) found an 8% improvement in carcass FCR when entire male pigs were compared with castrates. There was also a 6% numerical advantage in carcass daily gain for the entire males. MLC (1989) found that carcass FCR and ADG were improved by 11% and 3% respectively, for entire males compared with castrates. Genetic selection in the intervening years has meant that pigs are now leaner and convert feed to live weight much more efficiently since protein is deposited with greater efficiency than fat. For example back fat thickness in British commercial herds has been reduced from around 21 mm in 1971 to 11 mm in 1999 (MLC, 2000). With this in mind and the fact that slaughter weight is increasing in Ireland it is now opportune to again look at the effect of castration on both meat quality and pig performance.

Bringing females to heavier slaughter weights while finishing males at current weights by split sex feeding may also be an option. This would eliminate the need for castration which may become an

animal welfare concern in the future.

Improvements in the eating quality of pork may also be achieved by changing management practices prior to slaughter. Nutrition is the area where improvements are most likely to occur in this regard. Intramuscular fat, tenderness and juciness have all been shown to be affected by nutrition (Blanchard *et al*., 1999). Feeding *ad libitum cf.* restricted feeding during the finishing period has been associated with improvements in juciness, flavour and odour (MLC, 1989; Warkup *et al.,* 1990; Ellis *et al.,* 1990). The ratio of energy to protein in the diet can also impact on eating quality. Blanchard *et al.* (1999) compared a high energy low protein diet (14.7 MJ DE /kg, 166 g/kg protein, 7.0 g/kg lysine) with a diet containing conventional levels of energy and protein (14.2 MJ DE /kg, 205 g/kg protein, 10 g/kg lysine) in finishing pigs from 30 kg to 90 kg. The high energy and low protein diet had the highest level of intramuscular fat and the best eating quality. There is no information in the literature with regard to how long before slaughter the high energy and low protein diet must be fed before improvements in eating quality are observed.

This project investigated methods of increasing intramuscular fat and eating quality by increasing slaughter weight and adopting new nutritional and management practices. Increased slaughter weight will also benefit quality by providing larger joints which are necessary for some external markets and sectors of our own catering and processing trade. Increasing slaughter weights will benefit processors by reducing processing costs per kg of pig meat. Furthermore, increasing slaughter weight would mean that a greater proportion of pigmeat used in the processing and catering trades could be supplied domestically due to the production of larger joint sizes. Production of this meat in Ireland will ensure more reliable traceability of product back to producer level under the Bord Bia quality assurance scheme (Bord Bia, 1997).

3. Effect of diet supplementation with grass-meal on pig performance and on carcass composition

Introduction

Consumers have become more sophisticated, demanding and powerful. They now expect high standards of quality assurance with regard to food safety and eating quality. Animal welfare and environmental standards of production systems are also of interest to today's consumer.

Consumers often express concern over the eating quality of very lean pork. Higher levels of intra-muscular fat or marbling improve the juciness, tenderness and flavour of pork. About 2.0 to 2.5% of intra-muscular fat is thought to be required for optimal eating quality of pork. Genotype and nutrition may also modify eating quality with a high growth rate in the period before slaughter having a positive effect (Wood, 1997).

Intra-muscular fat levels in modern genotypes are often below 1% due mainly to intense selection for increased leanness. This helps to explain the deterioration in the eating quality of pork in recent years. Intra-muscular fat levels can be increased by using the Duroc breed with the added benefits of colour and texture improvements compared to Large White and Landrace pigs. These factors combine and result in a better eating experience for the consumer (D'Souza and Mullan, 2001)

Intra-muscular fat, tenderness and juiciness are all affected by nutrition (Blanchard *et al*., 1999). Feeding *ad-libitum* cf. restricted feeding during the finishing period has been associated with improvements in juiciness, tenderness, flavour and odour (MLC, 1989; Warkup *et al*., 1990; Ellis *et al*., 1990; Ellis *et al*. 1996). *Ad-libitum* fed pigs are both faster growing and fatter than pigs finished under feed restriction and both of these factors are likely to influence eating quality (Ellis and McKeith, 1993).

Feeding pigs at restricted intake level (0.8 of *ad-libitum* intake) from 30 to 75 kg with subsequent feeding at *ad-libitum* intake levels was found to improve eating quality compared with either restricted feeding or *ad-libitum* feeding from 30 to 90 kg. This suggests that rapid growth towards the end of the finishing period improves eating quality (Blanchard *et al*., 1999).

The ratio of energy to protein in the finishing diet can also impact on eating quality with high energy and low protein diets having the highest level of intra-muscular fat and the best eating

quality (Blanchard *et al*. 1999). It was suggested that it was in the last 5 to 6 weeks before slaughter that such a diet maximised lean tissue growth rate and that this was probably when eating quality and in particular tenderness was improved by feeding.

Vitamin E has been shown to reduce drip loss, improve colour stability and reduce off flavours in both fresh and processed pork products (D'Souza and Mullan, 2001, Rey *et al.,* 2001). The fatty acid profile of the pig carcass is easily altered by changing the fat source in the diet (D'Souza and Mullan, 2001).

The objectives of this study were to assess the effect of :

1. Terminal sire (Landrace or Duroc)
2. Diet supplementation with grass-meal
3. Increasing nutrient intake prior to slaughter
4. Vitamin E and optimisation of fatty acid balance
5. Supplemental tea extracts and optimisation of fatty acid balance

on the nutritional and eating quality of pig meat. This report looks only at the production effects of the above.

Materials and Methods

This experiment involved 864 pigs (72 single-sex groups of 14) from two sire lines (Duroc and Hylean Landrace) mated to F1 sows (first-cross progeny of Landrace boars on Large White dams) sourced from Hermitage AI, Sion Rd., Kilkenny, Ireland. Semen also sourced from Hermitage AI was a composite dose (5 boars) of either Hylean Landrace or Duroc on alternate weeks for 8 weeks (May – June 2001 and December – January 2002). In total 80 sows were served using Duroc semen and 80 sows are served using the Hylean semen. The progeny are described as Duroc or Hylean for the remainder of the report.

Pigs were weaned at 26 to 28 days of age. Pigs of similar weight were penned in same-breed, single-sex groups of 15 with no more than two pigs from any one litter in each group. Groups were blocked on breed, sex and weight and allocated at random to the treatments listed below. All groups were fed 25kg of Startrite 88™ (for 15 pigs) followed by Vigour™ to 21 days post-weaning at which time the experimental diets were fed. Startrite 88™ and Vigour™ were produced by SCA Nutrition, Monread Road, Naas Co. Kildare and were recommended for feeding to newly weaned

pigs and as a follow on to Startrite 88™, respectively.

Treatments were:

1. Hylean pigs fed concentrate diets to slaughter (Diet 1, Diet 2)
2. Hylean pigs fed concentrate diets with grass-meal up to slaughter (Diet 3, Diet 4).
3. Hylean pigs fed concentrate diets with grass-meal (Diet 3, Diet 4) to 50 kg live weight. From 50 kg to slaughter these pigs were fed a high nutrient dense finisher diet (Diet 2)
4. Hylean pigs fed concentrate diets with grass-meal (Diet 3, Diet 4) to 80 kg live weight. From 80 kg to slaughter pigs were fed a high nutrient dense finisher diet (Diet 2)
5. Hylean pigs fed concentrate diets with grass-meal (Diet 3, Diet 4) to 80 kg live weight. From 80 kg to slaughter these pigs were fed a vitamin E enriched (200 mg alpha-tocopheryl acetate/kg) diet with the fat inclusion from 00-rapeseed oil (Diet 5).
6. Hylean pigs fed concentrate diets with grass-meal (Diet 3, Diet 4) to 80 kg live weight. From 80 kg to slaughter these pigs were fed an antioxidant enriched diet (tea extracts to provide the equivalent of 200 mg alpha-tocopheryl acetate/kg) with the fat inclusion coming from 00-rapeseed oil (Diet 6).
7. Duroc pigs fed concentrate diets to slaughter (Diet 1, Diet 2)
8. Duroc pigs fed concentrate diets with grass-meal up to slaughter (Diet 3, Diet 4).
9. Duroc pigs fed concentrate diets with grass-meal (Diet 3, Diet 4) to 50 kg live weight. From 50 kg to slaughter these pigs were fed a high nutrient dense finisher diet (Diet 2)
10. Duroc pigs fed concentrate diets with grass-meal (Diet 3, Diet 4) to 80 kg live weight. From 80 kg to slaughter these pigs were fed a high nutrient dense finisher diet (Diet 2)
11. Duroc pigs fed concentrate diets with grass-meal (Diet 3, Diet 4) to 80 kg live weight. From 80 kg to slaughter pigs were fed a vitamin E enriched (200 mg/kg) diet with the fat inclusion from 00-rapeseed oil (Diet 5).
12. Duroc pigs fed concentrate diets with 100 g/kg grass-meal (Diet 3, Diet 4) to 80 kg live weight. From 80 kg to slaughter these pigs were fed an antioxidant enriched diet (tea extracts to provide the equivalent of 200 mg alpha-tocopheryl acetate /kg) with the fat inclusion from 00-rapeseed oil (Diet 6).

There were 6 replicates of each of the 12 treatments. Three replicates were carried out at each of 2 time periods (2001 and 2002). The layout of the treatments is shown in Table 3.1.

Table 3.1. Period during which high density (HD) or grass meal (GM) diets were fed to pigs

Days	Weight range	Treatment nos.					
	(Kg)	1 and 7	2 and 8	3 and 9	4 and 10	5 and 11	6 and 12
Weaning to d. 21	8 to 15	HD	HD	HD	HD	HD	HD
D. 21 to 54	15 to 33	HD	GM	GM	GM	GM	GM
D. 54 to 77	33 to 46	HD	GM	GM	GM	GM	GM
D. 77 to 117	46 to 80	HD	GM	HD	GM	GM	GM
D. 117 to 145	80 to 105	HD	GM	HD	HD	HD + vit. E	HD + tea extract

Ingredient composition and the analysed nutrient content of the sow diets and experimental diets are shown in Table 3.2 and 3.3 respectively. For the purposes of feed formulation, nutrient contents of the diets were estimated using the database of CVB (2001) and the feed formulation programme BestMix™ (ADIFO, Belgium). The declared composition of the commercial diets Startrite 88™ and Vigour™ is shown in Table 3.4.

Corrected slaughter weight

The following equation was used to calculate corrected slaughter weight:

Cold carcass weight / 0.77188

The corrected slaughter weight was used to approximate the empty live-weight at slaughter excluding gastro-intestinal tract contents.

Compensatory growth index

The occurrence of compensatory growth was studied by comparing differences in live-weight at the end of the restriction period relative to the corresponding differences in weight at slaughter (compensatory index; Hornick *et al.,* 2000). The index was calculated using the following formulae:

(A-B)/A*100

where A = weight at end of restriction period and B = weight at end of re-alimentation period (adjusted to the same number of days in the re-alimentation period).

Statistical Analysis

Statistical analysis was by the PROC GLM procedure of SAS Inc, Cary, N. Carolina for a split plot design with covariance as appropriate. Factors in the model were year, sex, diet, breed, breed x diet, breed x sex, breed x sex x diet. Duncans Multiple Range test was used to compare diet means.

Table 3.2. Ingredient composition of experimental diets (g/kg)

Diet number	**Diet 1**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	**Diet 6**
Diet type	**Weaner**	**Finisher**	**Weaner**	**Finisher**	**Finisher**	**Finisher**
Barley	225	540	202.5	432.4	522	522
Wheat	312.0	214.0	280.7	172.0	204.0	204.0
Maize	100	0	90	0	0	0
Soya Hi-Pro	290	215	261	171	204	204
Fat (lard)	50	10	45	8	0	0
Rapeseed oil (00)	0	0	0	0	50	50
Grassmeal	0	0	100	200	0	0
Lysine HCl	3.0	2.5	2.7	2.0	2.4	2.4
DL-Methionine	1.0	0.7	0.9	0.5	0.67	0.67
L-Threonine	1.5	0.7	1.3	0.5	0.67	0.67
Di Cal Phos	0	0	0	0	0	0
Limestone Flour	11.4	13.0	10.4	10.4	12.4	12.4
Salt	3.0	3.0	2.7	2.4	2.85	2.85
Vit-Mins	3.0	1.0	2.7	0.8	0.95	0.95
Phytase 5000, iu/g[1]	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin E					+	
Tea extracts						+

[1,]Phytase: Natuphos (BASF, Germany) 5000 FTU/gm equal to 500 FTU per kg finished feed.

Table 3.3. Analysed chemical composition of experimental diets (g/kg)

Diet number	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Diet type	**Weaner**	**Finisher**	**Weaner**	**Finisher**	**Finisher**	**Finisher**
Proximate analysis						
Crude protein	210	181	205	184	177	178
Oil	63	32	59	28	67	63
Crude fibre	29	34	45	68	33	35
Ash	44	41	46	48	40	40
Starch	359	396	323	314	376	377
Minerals						
Calcium	7.4	7.4	6.6	7.5	7.1	6.8
Phosphorus	3.9	3.7	3.7	3.6	3.6	3.7
Potassium	10.1	8.5	10.4	10.3	9.1	8.2
Magnesium	1.7	1.5	1.7	1.7	1.5	1.5
Sodium	1.4	1.3	1.5	1.6	1.5	1.3
Sulphur	2.3	2.1	2.6	2.7	2.1	1.9
Manganese, mg/kg	54	37	58	56	35	35
Zinc, mg/kg	167	105	167	85	98	98
Copper, mg/kg	144	162	122	86	109	109
Iron, mg/kg	242	128	314	238	138	110
Amino acids						
Lysine	12.8	10.5	11.7	9.6	10.3	10.2
Methionine	3.8	3.1	3.5	2.8	3.1	3.0
Cystine	3.2	2.9	2.9	2.6	2.8	2.8
Meth+Cyst	6.9	6.0	6.4	5.4	5.8	5.8
Threonine	8.7	6.9	8.2	6.7	6.7	6.7
Tryptophane	2.7	2.3	2.7	2.4	2.2	2.2
Isoleucine	8.6	7.1	8.0	7.0	6.9	7.0
Leucine	15.3	12.5	14.2	12.3	12.1	12.3
Phenyl	10.1	8.7	9.5	8.3	8.4	8.6
Tyros	6.4	5.3	6.1	5.2	5.3	5.2
Phenyl + Tyros	16.5	14.0	15.5	13.5	13.7	13.8
Valine	9.6	8.3	9.1	8.4	8.0	8.3
Aspartic	19.7	15.5	18.7	16.1	15.1	15.4
Serine	9.9	8.3	9.1	7.9	7.9	7.9
Glutamic	40.7	34.6	37.0	32.9	34.7	35.0
Glycine	8.5	7.3	8.1	7.4	7.1	7.1
Histidine	5.0	4.2	4.6	4.0	4.0	4.0
Arginine	13.2	10.7	11.9	10.0	10.5	10.4
Alanine	8.9	7.3	8.6	7.8	7.1	7.2

Table 3.4. Declared composition of commercial diets Startrite 88[1] and Vigour[1] g/kg

	Startrite 88™	Vigour™
Crude protein	220	200
Oil	95	75
Crude fibre	22	25
Ash	65	70
Vitamin A, miu/t	13	13
Vitamin D_3, miu/t	2.0	2.0
Vitamin E, 000iu/t	250	200
Lysine	16.2	14.0
Phosphorus (total)	5.8	5.4
Copper as $CuSO_4$ (added, mg/kg)	160	160
Zinc as ZnO (added, mg/kg)	2,400	2,400
Iron as $FeSo_4.7H_2O$ (added, mg/kg)	200	200
Pulmotil (Tilmicosin)[2],mg/kg	0	200

[1] SCA Nutrition, Monread Road, Naas,. Co. Kildare

[2] Elanco Animal Health, Kinsale, Co. Cork.

Results

The determined *in vitro* enzyme digestible organic matter (EDOM) and energy digestibility values for the diets are shown in Table 3.5. This analysis was performed at the Danish Institute of Agricultural Science, Foulum, Denmark.

Table 3.5. EDOM and energy digestibility of diet samples

Diet no.	Dry matter, g/kg	Ash, g/kg	EDOM	Energy digestibility, %
1	889.0	47.6	91.4	87.09
2	876.5	43.4	89.7	85.21
3	888.7	51.2	87.8	83.11
4	883.7	54.7	82.3	77.02
5	888.9	44.5	89.7	85.21
6	889.9	44.0	89.1	84.54

The main effect of diet on pig performance is shown in Tables 3.6 to 3.11 and the effects of sex and breed are shown in Tables 3.12 to 3.15. There was no significant breed by dietary treatment interaction ($P>0.05$) so results are presented for main effects only. Pigs from Landrace sires grew at a similar rate but had better feed conversion ratio (FCR) from weaning to slaughter than Duroc

pigs (2.55 v 2.65; P<0.10). Landrace pigs also had higher carcass lean content than Durocs (596 v 592 g/kg; P<0.01).

Feeding the GM diet depressed growth rate, FCR and kill out yield (P<0.05). Backfat depth was decreased on the GM diet (P<0.05) but carcass lean was not affected. Feeding GM for shorter periods resulted in intermediate performance. Dietary antioxidant improved FCR (P<0.05) but had no other effect.

Effect of diet from weaning to day 54 (Table 3.6)

Pig weights. Pig weights on the six dietary treatments were not significantly different (P>0.05) at weaning, day 21 or on transfer to the finishing house at day 54.

Daily gain, daily feed intake and FCR. There were no significant differences between treatments in daily gain, daily feed intake and FCR in the periods weaning to day 21, day 21 to 54 or weaning to day 54.

Table 3.6. Effect of diet on pig performance from weaning to c. 30kg (= day 54) (Two breeds combined)

Treatment no.	**1**	**2**	**3**	**4**	**5**	**6**	**Sem**	**P %**
No groups	**12**	**12**	**12**	**12**	**12**	**12**		
No pigs per pen [1]	14.6	14.4	14.4	14.3	14.5	14.2	0.19	73
Pig weights, kg								
Weaning wt.	8.2	8.2	8.3	8.4	8.6	8.3	0.46	99
Day 21	15.2	15.0	15.1	15.3	15.7	15.3	0.56	97
Day 54	33.5	32.9	32.8	32.9	34.1	33.6	0.88	87
Weaner Stage 1 (day 0 to 21)								
Days	21.0	21.0	21.0	21.0	21.1	21.0	0.03	43
Age at end of period, d	47.0	47.0	47.0	47.0	47.1	47.0	0.03	43
Daily gain, g	332	326	324	329	335	329	10.1	97
Daily feed, g	347	334	335	355	354	334	14.3	78
Feed conversion ratio	1.04	1.03	1.03	1.08	1.06	1.01	0.024	42
Weaner stage 2 (day 21 to 54)								
Days	33.8	34.0	33.9	33.7	33.8	33.9	0.40	99
Age at end of period, d	80.8	81.1	80.9	80.7	80.9	80.9	0.40	99
Daily gain, g	539	544	519	524	546	542	15.2	73
Daily feed, g	932	954	928	947	965	970	23.7	76
Feed conversion ratio	1.74	1.77	1.79	1.82	1.77	1.79	0.040	78
Weaner stages 1 and 2 (day 0 to 54)								
Days	54.8	55.1	54.9	54.7	54.9	54.9	0.39	99
Daily gain, g	460	461	445	449	465	461	11.1	76
Daily feed, g	708	717	702	720	730	727	18.7	88
Feed conversion ratio	1.54	1.57	1.58	1.61	1.57	1.58	0.030	79

[1] *Number per pen at the end of weaner stage 2 (day 54)*

Effect of diet from day 54 to slaughter (Table 3.7)

Pig weights. Pig weights on the six dietary treatments were not significantly different (P>0.05) at day 77. Pigs on the control treatment (Treatment 1) were heavier at day 117 than those on treatments 2 and 4 (P<0.05). Treatments 3, 5 and 6 did not differ significantly from any other treatment. At slaughter, pigs on treatment 1 were heavier than those on treatments 2 and 6 (P<0.05). Other treatment differences were not significant.

Daily gain, daily feed intake and FCR from day 54 to 77

Pigs on treatment 1 grew faster and more efficiently (P<0.05) than those on the other five diets which did not differ significantly from one and other (P>0.05). Differences in daily feed intake were not significant (P>0.05).

Daily gain, daily feed intake and FCR from day 77 to 117

Pigs on treatment 1 grew faster (P<0.05) than those on treatments 2, 4 and 5 which did not differ significantly from one another (P>0.05). Growth rate on treatment 6 was not different from the other 5 treatments. FCR on treatments 1 and 3 was significantly better (P<0.05) than on the other 4 treatments. FCR on treatment 4 was poorer than on any other treatment (P<0.05). Differences in daily feed intake were not significant (P>0.05).

Daily gain, daily feed intake and FCR from day 117 to slaughter

Pigs on treatments 4 and 5 grew faster (P<0.05) than those on treatment 2 (P<0.05) while other treatment differences were not significant (P>0.05). FCR on treatments 3 was significantly poorer (P<0.05) than on the other 5 treatments which did not differ significantly from one another (P>0.05). Differences in daily feed intake were not significant (P>0.05).

Daily gain, daily feed intake and FCR from day 54 to slaughter

Pigs on treatment 1 grew faster (P<0.05) than those on all other treatment 2 (P<0.05) while those on treatments 3 and 6 grew significantly faster than those on treatment 2 (P<0.05) but not significantly different from those on treatments 4 and 5. FCR on treatment 1 was significantly better (P<0.05) than on the other 5 treatments. FCR on treatment 3 was significantly better (P<0.05) than on 4 treatments (2, 4, 5 and 6). FCR was poorest on 2 and 4 which were significantly different from 5 and 6. Differences in daily feed intake were not significant (P>0.05).

Table 3.7. Effect of diet on pig performance from 30kg to slaughter (Two breeds combined)

	1	*2*	*3*	*4*	*5*	*6*	*sem*	*P %*
No groups	12	12	12	12	12	12		
Pigs per pen[1]	13.8	14.1	14.0	13.7	13.7	13.6	0.32	85
Pig weights, kg								
Day 54	33.5	32.9	32.8	32.9	34.1	33.6	0.88	87
Day 77	47.9	44.4	44.6	45.7	46.2	45.9	1.13	29
Day 117	82.1 [a]	75.3 [b]	78.8 [ab]	74.9 [b]	77.3 [ab]	78.3 [ab]	1.80	8 +
Slaughter	107.2 [a]	103.7 [b]	105.9 [ab]	104.4 [ab]	104.2 [ab]	103.9 [b]	0.98	10+
Finisher stage 1 (day 54 to 77)								
Days	21.7	21.3	21.9	22.2	21.4	21.2	0.70	91
Age end of period, d	102.5	102.4	102.8	102.8	102.3	102.1	0.40	74
Daily gain, g	660 [a]	539 [b]	538 [b]	565 [b]	554 [b]	571 [b]	18.8	**
Daily feed, g	1518	1564	1515	1588	1587	1589	40.1	58
Feed conversion ratio	2.31 [a]	2.94 [b]	2.86 [b]	2.82 [b]	2.88 [b]	2.79 [b]	0.073	**
Finisher stage 2 (day 77 to 117)								
Days	40.5	40.5	40.1	40.1	40.5	40.9	0.39	66
Age end of period, d	143.0	142.9	142.9	142.9	142.8	143.0	0.09	79
Daily gain, g	844 [a]	762 [b]	853 [a]	730 [b]	770 [b]	793 [ab]	24.4	**
Daily feed, g	2130	2115	2145	2154	2178	2208	59.3	90
Feed conversion ratio	2.53 [a]	2.78 [b]	2.52 [a]	2.97 [c]	2.83 [b]	2.80 [b]	0.037	**
Finisher stage 3 (day 117 to slaughter)								
Days	30.3	36.6	32.0	34.1	31.3	30.1	2.33	33
Age end of period, d	173.3	179.5	174.9	177.0	174.2	173.1	2.32	34
Daily gain, g	829 [ab]	784 [b]	847 [ab]	884 [a]	875 [a]	862 [ab]	26.1	10
Daily feed, g	2608	2697	2592	2770	2683	2649	59.4	32
Feed conversion ratio	3.18 [a]	3.45 [b]	3.08 [a]	3.15 [a]	3.09 [a]	3.09 [a]	0.073	**
Combined finisher (day 54 to slaughter)								
Days	92.4	98.4	94.0	96.3	93.3	92.2	2.28	32
Daily gain, g	800 [a]	720 [c]	779 [b]	744 [bc]	754 [bc]	764 [b]	14	**
Daily feed, g	2145	2208	2150	2235	2210	2203	37	44
Feed conversion ratio	2.69 [a]	3.07 [b]	2.77 [d]	3.01 [b]	2.93 [c]	2.88 [c]	0.02	**
Daily carcass gain, g	671 [a]	588 [c]	647 [ab]	618 [bc]	627 [b]	634 [b]	12.0	**
Carcass FCR	3.20 [e]	3.76 [a]	3.31 [d]	3.63 [b]	3.53 [c]	3.47 [c]	0.030	**

[1] Number per pen at slaughter

Effect of diet from weaning to slaughter (Table 3.8)

Pigs on treatment 1 grew significantly faster (P<0.05) than pigs on treatments 2 and 4 with all other treatments not being significantly different from treatment 1. Feed conversion efficiency was better for treatments 1 and 3 than treatments 2 and 4 which were in turn more efficient than treatments 5 and 6 (P<0.05). Daily carcass gain was higher for treatment 1 than all other treatments except treatments 3 and 6 which were similar (P<0.05). Carcass FCR most efficient for treatment 1, followed by treatment 3, followed by treatments 5 and 6, followed by treatment 4, with treatment 2 having the poorest FCR of all (P<0.05).

Table 3.8. Effect of diet on pig performance from weaning to slaughter (Two breeds combined)

	1	*2*	*3*	*4*	*5*	*6*	*sem*	*P %*
No groups	**12**	**12**	**12**	**12**	**12**	**12**		
Weaning to day 77								
Days	76.5	76.4	76.8	76.8	76.3	76.1	0.40	74
Daily gain, g	517 [a]	482 [ab]	471 [b]	482 [ab]	490 [ab]	492 [ab]	11.1	11
Daily feed, g	939	954	933	970	972	968	22.4	74
Feed conversion ratio	1.82 [a]	1.98 [b]	1.99 [b]	2.02 [b]	1.98 [b]	1.97 [b]	0.026	**
Day 77 to slaughter								
Days	70.8	77.1	72.1	74.2	71.8	71.0	2.41	43
Daily gain, g	844 [a]	771 [c]	853 [a]	798 [ab]	816 [ab]	824 [ab]	19.3	5 *
Daily feed, g	2337	2388	2346	2432	2399	2391	46.6	72
Feed conversion ratio	2.78 [c]	3.10 [a]	2.76 [c]	3.06 [a]	2.95 [b]	2.91 [b]	0.033	**
Weaning to slaughter								
Days	147.3	153.5	148.9	151.0	148.2	147.1	2.32	34
Daily gain, g	730 [a]	675 [b]	710 [ab]	686 [b]	698 [ab]	704 [ab]	12.8	7 +
Daily feed, g	1818	1885	1820	1899	1877	1870	26.7	16
Feed conversion ratio	2.43 [a]	2.74 [b]	2.50 [a]	2.70 [b]	2.62 [c]	2.59 [c]	0.024	**
Daily carcass gain, g	535 [a]	484 [c]	518 [ab]	502 [bc]	509 [b]	512 [ab]	8.1	**
Carcass FCR	3.40 [e]	3.90 [a]	3.52 [d]	3.79 [b]	3.69 [c]	3.65 [c]	0.027	**

Carcass gain and carcass FCR use cold weight as the final weight and assume carcass to be 60% and 65% of live weight at weaning and transfer respectively

Effect of diet on pig performance from day 54 to a corrected slaughter weight (Table 3.9)

The corrected slaughter weight and corrected daily gain was higher for treatment 1 than for treatments 2, 4, 5, and 6 with treatment 3 having a corrected slaughter weight which was similar to that of treatment 1 (P<0.05). The corrected FCR was better for treatment 1 than for all other treatments (P<0.05).

Table 3.9. Effect of diet on pig performance from day 54 to a corrected slaughter weight (Two breeds combined)

	1	*2*	*3*	*4*	*5*	*6*	*Sem*	*P %*
No groups	**12**	**12**	**12**	**12**	**12**	**12**		
Actual slaughter wt, kg	107.2 [a]	103.7 [b]	105.9 [ab]	104.4 [ab]	104.2 [ab]	103.9 [b]	0.98	10+
Corrected slaughter wt., kg	108.2 [a]	102.5 [c]	106.3 [ab]	104.4 [bc]	104.1 [bc]	103.8 [bc]	0.08	**
Daily gain (corrected), g	812 [a]	708 [c]	783 [ab]	746 [bc]	754 [b]	764 [b]	13.7	**
FCR (corrected)	2.65 [e]	3.12 [a]	2.75 [d]	3.00 [b]	2.93 [bc]	2.89 [c]	0.026	**

Effect of diet on nitrogen and phosphorus intake (Table 3.10)

Nitrogen intake for treatment 1 was not significantly different to that of treatments 3 and 6, however N intake was higher for treatments 2, 4 and 5 than for treatment 1 ($P<0.05$). Phosphorus intake was similar for treatments 1, 3, 5 and 6 with treatments 2 and 4 being significantly higher ($P<0.05$).

Table 3.10. Effect of diet on nitrogen and phosphorus intake from weaning to slaughter (Two breeds combined)

	1	*2*	*3*	*4*	*5*	*6*	*Sem*	*P %*
No groups	**12**	**12**	**12**	**12**	**12**	**12**		
N intake, kg	7.00 [c]	7.68 [a]	7.13 [bc]	7.59 [a]	7.25 [b]	7.19 [bc]	0.081	**
Phosphorus intake, g	944 [b]	999 [a]	947 [b]	987 [a]	959 [b]	956 [b]	10.1	**

Effect of diet on carcass traits (Table 3.11)

Carcass weight and kill out yield was higher ($P<0.05$) for treatment 1 than for all other treatments except treatment 3, which was not significantly different. Carcass lean was not affected by dietary treatment ($P>0.05$).

Table 3.11. Effect of diet on carcass traits (Two breeds combined)

	1	*2*	*3*	*4*	*5*	*6*	*Sem*	*P %*
No groups	**12**	**12**	**12**	**12**	**12**	**12**		
Hot carcass wt	85.2 [a]	80.7 [c]	83.7 [ab]	82.2 [bc]	82.0 [bc]	81.8 [bc]	0.82	**
Cold carcass wt., kg	83.5 [a]	79.1 [c]	82.1 [ab]	80.6 [bc]	80.4 [bc]	80.1 [bc]	0.81	**
Kill out, g/kg	779 [a]	763 [c]	775 [ab]	772 [b]	771 [b]	771 [b]	2.3	**
Carcass lean, g/kg	594	596	594	596	592	593	1.3	40
Backfat, mm	12.2 [a]	10.6 [c]	11.9 [a]	11.2 [bc]	11.7 [ab]	11.7 [ab]	0.21	**
Muscle, mm	59.0 [a]	55.1 [d]	58.3 [ab]	56.5 [cd]	56.7 [bcd]	57.5 [abc]	0.55	**

Effect of breed and sex on pig performance from weaning to day 54 post-weaning (Table 3.12)

From weaning to day 54 post-weaning Duroc pigs had a higher feed intake (P<0.05) and poorer FCR (P<0.01) than Hylean pigs. During the same period females had a higher feed intake (P<0.01) and higher daily gain (P<0.01) than males.

Table 3.12. Effect of breed and sex on pig performance from weaning to c. 30kg (day 54).

	Duroc	**Hylean**	**P %**	**Female**	**Male**	**P %**
No groups	**36**	**36**		**36**	**36**	
No pigs per pen	14.4	14.4	86	14.6	14.2	**
Pig weights, kg						
Weaning wt.	8.2	8.4	66	8.3	8.4	74
Day 21	15.3	15.2	86	15.2	15.3	85
Transfer to finishing house	33.3	33.3	90	34.1	32.5	3 *
Weaner Stage 1 (day 0 to 21)						
Days	21.0	21.0	32	21.0	21.0	32
Age at end of period, d	47.0	47.0	32	47.0	47.0	32
Daily gain, g	336	323	13	331	328	73
Daily feed, g	354	333	77	347	340	59
Feed conversion ratio	1.05	1.03	23	1.05	1.04	56
Weaner stage 2 (day 21 to 54)						
Days	34.1	33.6	11	33.8	33.9	67
Age at end of period, d	81.1	80.6	13	80.8	81.0	61
Daily gain, g	533	538	70	565	507	**
Daily feed, g	969	930	5 +	987	912	**
Feed conversion ratio	1.83	1.73	**	1.75	1.81	10
Weaner stages 1 and 2 (day 0 to 54)						
Days	55.1	54.6	13	54.8	55.0	61
Daily gain, g	458	455	77	475	438	**
Daily feed, g	734	700	3 *	742	693	**
Feed conversion ratio	1.61	1.54	**	1.56	1.58	41

Effect of breed and sex on pig performance from 30kg (day 54) to slaughter (Table 3.13)

Between day 54 and day 77 daily gain was higher for Hylean than Duroc (P<0.05). Feed conversion efficiency was better for Hylean in the periods between day 54 and 77 (P<0.01), day 77 and 117 (P<0.05) and day 54 to slaughter (P<0.01).

Feed intake was higher for females than males in the periods between day 54 and 77 ($P<0.05$), day 77 to 117 ($P<0.01$), day 117 to slaughter ($P<0.01$) and day 54 to slaughter ($P<0.01$). In the period from day 117 to slaughter daily gain was higher for males than females ($P<0.01$) and in the period between day 54 and slaughter there was a tendency for males to have a higher ($P=0.06$) daily gain than females. Feed conversion efficiency was better for males than females in the periods between day 77 and 117 ($P<0.01$), day 117 to slaughter ($P<0.01$), day 54 to slaughter ($P<0.01$) and day 54 to slaughter ($P<0.01$).

Table 3.13. Effect of breed and sex on pig performance from 30kg(day 54) to slaughter

	Duroc	Hylean	P %	Female	Male	P %
No groups	**36**	**36**		**36**	**36**	
Pigs per pen	14.0	13.6	10 +	14.1	13.5	*
Pig weights, kg						
Transfer to finishing house	33.3	33.3	90	34.1	32.5	3 *
Finisher interim wt. (c. 50kg)	45.0	46.5	11	46.8	44.8	3 *
Finisher interim wt. (c. 80kg)	77.0	78.6	28	78.5	77.1	34
Slaughter wt.	105.0	104.8	82	105.3	104.5	34
Finisher stage 1 (day 54 to 77)						
Days	21.1	22.1	10	21.7	21.5	77
Age end of period, d	102.3	102.7	18	102.5	102.5	100
Daily gain, g	551	591	1 *	579	564	35
Daily feed, g	1580	1540	22	1601	1519	1 *
Feed conversion ratio	2.90	2.64	**	2.80	2.73	25
Finisher stage 2 (day 77 to 117)						
Days	40.7	40.2	10	40.5	40.4	66
Age end of period, d	143.0	142.9	26	143.0	142.9	6 +
Daily gain, g	785	799	51	783	801	39
Daily feed, g	2162	2148	78	2246	2064	**
Feed conversion ratio	2.77	2.71	5 *	2.89	2.59	**
Finisher stage 3 (day 117 to slaughter)						
Days	33.9	30.8	11	33.1	31.7	47
Age end of period, d	176.9	173.7	10 +	176.1	174.6	42
Daily gain, g	838	855	43	816	877	**
Daily feed, g	2657	2676	70	2757	2576	**
Feed conversion ratio	3.19	3.17	73	3.40	2.95	**
Combined finisher (day 54 to slaughter)						
Days	95.8	93.1	15	95.3	93.6	36
Daily gain, g	751	769	13	749	772	6 +
Daily feed, g	2307	2177	32	2275	2109	**
Feed conversion ratio	2.94	2.84	**	3.05	2.74	**
Daily carcass gain, g	624	638	13	631	631	97
Carcass FCR	3.54	3.42	**	3.62	3.35	22

Effect of breed and sex on performance from weaning to slaughter (Table 3.14)

In the period between weaning and day 77 feed intake was higher (P<0.05), daily gain was higher

(P<0.05) and FCR was more efficient (P<0.01) for Hylean than Duroc.

Daily feed intake was higher for females than males between weaning and day 77 (P<0.01), day 77 to slaughter (P<0.01) and between weaning and slaughter (P<0.01), respectively. In the period between weaning and day 77 daily gain was higher for females than males (P<0.01) but between day 77 and slaughter daily gain was higher for males than females (P<0.05). Feed conversion efficiency was better for males than females between day 77 and slaughter (P<0.01) and between weaning and slaughter (P<0.01), respectively.

Table 3.14. Effect of breed and sex on performance from weaning to slaughter

	Duroc	**Hylean**	**P %**	**Female**	**Male**	**P %**
No groups	**36**	**36**		**36**	**36**	
Weaning to 50kg (day 77)						
Days	76.3	76.7	30	76.5	76.5	100
Daily gain, g	484	494	5 *	504	474	**
Daily feed, g	970	942	5 *	986	926	**
Feed conversion ratio	2.01	1.91	1 *	1.96	1.96	99
50kg (day 77) to slaughter						
Days	74.6	71.0	6 +	73.6	72.1	35
Daily gain, g	810	825	41	800	835	1 *
Daily feed, g	2387	2377	88	2476	2289	**
Feed conversion ratio	2.96	2.90	17	3.10	2.75	**
Weaning to slaughter						
Days	150.9	147.7	12	150.1	148.6	37
Daily gain, g	694	707	29	700	701	94
Daily feed, g	1881	1843	43	1936	1787	**
Feed conversion ratio	2.65	2.55	10	2.71	2.49	**
Daily carcass gain, g	506	514	14	515	505	7 +
Carcass FCR	3.72	3.59	22	3.78	3.54	**

Effect of breed and sex on carcass traits (Table 3.15)

Carcass lean was higher for Hylean pigs than Duroc pigs (P<0.01). Cold carcass weight, kill out yield and carcass lean were all higher for females than males (P<0.01).

Table 3.15. Effect of breed and sex on carcass traits

	Duroc	Hylean	P %	Female	Male	P %
No groups	**36**	**36**		**36**	**36**	
Hot carcass wt						
Cold carcass wt., kg	81.1	80.8	61	82.0	79.9	**
Kill out, g/kg	773	771	77	779	765	**
Carcass traits						
Carcass lean, g/kg	592	596	**	596	592	**
Backfat, mm	11.6	11.5	36	11.7	11.4	12
Muscle, mm	56.5	57.8	**	58.6	55.7	**

Carcass gain and carcass FCR use cold weight as the final weight and assume carcass to be 60% and 65% of live weight at weaning and transfer respectively

Compensatory growth (Tables 3.16-3.19)

Compensatory growth may be defined as a physiological process whereby growth is accelerated after a period of restricted development, due to reduced energy intake, such that the animal's weight equals or approaches that of animals whose growth was never reduced (Hornick *et al*., 2000). Economic (reduced feed costs), environmental (reduced output of nutrients) and meat quality benefits may result from the exploitation of compensatory growth in pigs.

The degree of compensatory growth in this study was examined using the compensatory growth index of Hornick *et al.,* (2000). The compensatory growth index may depend on factors such as the restriction period (length, developmental stage, severity), re-alimentation period (length, feed intake, diet composition), genotype and sex. These factors were all considered when examining the data from this study. The compensatory growth index for a restriction period between day 21 and 77 post weaning is shown in Table 3.18. Sex and breed effects are separated out and the weight at the end of the re-alimentation period was adjusted to the same number of days in the re-alimentation period. The compensatory growth index for a restriction period between day 21 and 117 post weaning is shown in Table 3.19. Sex and breed effects are separated out and the weight at the end of the re-alimentation period was also adjusted to the same number of days in the re-alimentation period.

From Table 3.18, it can be seen that where compensatory growth did occur (3 out of 4 calculated indices) it was only partial in 2 indices. Table 3.19 shows that 9 out of 12 calculated indexes demonstrated compensatory growth, however compensatory growth was only partial in each case.

It should be noted that means of only 3 pens were available to calculate the compensatory growth index in Tables 3.18 and 3.19. For this reason the information is indicative only.

Table 3.16. Production Performance (LS-means) of pigs during feed restriction (A, day 21 to day 77 post weaning) and during re-alimentation (B, day 77 post-weaning to slaughter).[1]

	Breed	Treatment			
		1		3	
		B	G	B	G
Initial weight, kg	D	14.9	15.1	14.4	15.6
	L	14.8	15.9	15.4	14.9
Weight day 77, kg	D	46.5	46.6	41.3	44.3
	L	48.2	50.4	46.7	46.1
Slaughter weight, kg	D	107.9	107.4	104.5	107.3
	L	107.9	105.9	108.4	103.6
Feed consumed A, MJ NE/day	D	11.5	11.5	10.2	11.7
	L	10.6	11.9	10.4	10.7
Feed consumed B, MJ NE/day	D	21.1	22.7	20.8	23.6
	L	21.0	21.2	21.2	21.4
ADG A, g/day	D	562	580	482	515
	L	596	623	559	558
ADG B, g/day	D	860	804	856	841
	L	848	816	875	822
Energy conversion A, MJ NE/kg gain	D	20.5	19.8	21.2	21.5
	L	17.8	19.1	18.6	19.2
Energy conversion B, MJ NE/kg gain	D	24.5	28.3	24.2	28.1
	L	24.9	26.0	24.2	26.1

Treatment no. 1: Ad-lib; 3: Restricted
D: Duro; L: Landrace
B: Entire male; G: Gilt
[1]*Adjusted to the same number of days in the re-alimentation period*

Table 3.17. Production performance (LS-means) of pigs during feed restriction (A, day 21 to day 117 post weaning) and during re-alimentation (B, day 117 post-weaning to slaughter)[1].

	Breed	Treatment							
		1		4		5		6	
		B	G	B	G	B	G	B	G
Initial weight, kg	D	14.9	15.1	15.9	14.9	15.3	15.9	15.2	16.1
	L	14.8	15.9	15.0	15.3	15.6	15.8	15.2	14.7
Weight day 117, kg	D	81.1	78.9	73.6	73.5	77.1	78.4	78.9	79.6
	L	82.2	86.2	75.5	77.1	75.9	77.9	78.1	76.4
Slaughter weight, kg	D	107.9	107.6	105.1	102.8	106.3	103.0	101.3	105.9
	L	107.8	105.9	107.0	102.7	102.4	105.2	103.9	104.6
Feed consumed A, MJ NE/day	D	14.8	15.1	13.7	14.5	13.8	15.3	13.9	15.6
	L	14.3	15.6	13.4	14.5	13.4	14.3	13.7	14.2
Feed consumed B, MJ NE/day	D	23.6	25.0	22.7	25.2	26.4	28.2	24.1	28.9
	L	24.1	22.9	23.3	24.1	26.3	29.0	26.7	28.1
ADG A, g/day	D	690	665	600	612	643	651	663	662
	L	702	733	632	644	634	647	655	644
ADG B, g/day	D	870	786	854	899	933	823	795	847
	L	886	743	935	873	940	790	976	795
Energy conversion A, MJ NE/kg gain	D	21.4	22.7	22.8	23.7	21.4	23.5	21.0	23.5
	L	20.3	21.3	21.3	22.6	21.1	22.1	21.0	22.0
Energy conversion B, MJ NE/kg gain	D	24.6	28.9	26.7	26.3	23.0	28.5	26.4	27.8
	L	22.9	28.6	22.8	25.9	22.5	28.0	21.5	27.7

Treatment no. 1: Ad-lib; 4, 5, 6: restricted, D: Duroc; L: Landrace, B: Entire male; G: Gilt, [1]Adjusted to the same number of days in the re-alimentation period

Table 3.18. Compensatory growth index for pigs restricted between day 21 and day 77 post weaning[1]

		Treatment		Difference[2]	Index[3]
	Sex	**1**	**3**	**1-3**	**1-3**
Restriction Period (A)					
Duroc					
End weight, kg	B	46.5	41.3	5.2	
End weight, kg	G	46.6	44.3	2.3	
Landrace					
End weight, kg	B	48.2	46.7	1.5	
End weight, kg	G	50.4	48.1	2.3	
Re-alimentation period (B)					
Duroc					
End weight, kg	B	107.9	104.5	3.4	35
End weight, kg	G	107.4	107.3	0.1	96
Landrace					
End weight, kg	B	107.9	108.4	-0.5	133
End weight, kg	G	105.9	103.6	2.3	0

[1] *Adjusted to the same number of days in the re-alimentation period*

[2] *1-3: Treatment 1 – Treatment 3*

[3] *Index = (A-B)/A*100 where A = weight at end of restriction period and B = weight at end of re-alimentation period.*

Table 3.19. Compensatory growth index for pigs restricted between day 21 and day 117 post weaning[1]

		Treatment				Difference[2]			Index[3]		
	Sex	1	4	5	6	1-4	1-5	1-6	1-4	1-5	1-6
Restriction Period (A)											
Duroc											
End weight, kg	B	81.1	73.6	77.1	78.9	7.5	4.0	2.2			
End weight, kg	G	78.9	73.5	78.4	79.6	5.4	0.5	-0.7			
Landrace											
End weight, kg	B	82.2	75.5	75.9	78.1	6.7	6.3	4.1			
End weight, kg	G	86.2	77.1	77.9	76.4	9.1	8.3	9.8			
Re-alimentation period (B)											
Duroc											
End weight, kg	B	107.9	105.1	106.3	101.3	2.8	1.6	6.6	63	60	-200
End weight, kg	G	107.6	102.8	103.0	105.9	4.8	4.6	1.7	11	-820	343
Landrace											
End weight, kg	B	107.8	107.0	102.4	103.9	0.8	5.4	3.9	88	14	5
End weight, kg	G	105.9	102.7	105.2	104.6	3.2	0.7	1.3	65	92	87

[1] *Adjusted to the same number of days in the re-alimentation period*

[2] *1-3 = Treatment 1 – Treatment 3; 1-4 = Treatment 1 – Treatment 4; 1-5 = Treatment 1 – Treatment 5; 1-6 = Treatment 1 – Treatment 6.*

[3] *Index = (A-B)/A*100 where A = weight at end of restriction period and B = weight at end of re-alimentation period.*

Efficiency of utilization of Nitrogen and Phosphorous (Table 3.20)

Treatment 2 and treatment 4 (where a high level of grass meal was fed) had the highest input (P<0.001), highest output (P<0.001) and poorest efficiency of utilization (P<0.001) of all the treatments for both P and N. Treatments 1 and 3 had the lowest input (P<0.001), lowest output (P<0.001) and best efficiency of utilization (P<0.001) of all the treatment for both P and N. This indicates that conventional feeding (Treatment 1) of pigs is more environmentally beneficial than using compensatory growth, particularly if the period of restricted feeding is long (Treatments 4, 5 and 6).

An interesting finding from the study was that when 5% rapeseed oil diets were fed (Treatment 5 and 6) from 80kg to slaughter N and P efficiency was significantly increased compared with Treatment 4, where the diet contained 1% lard. Strudsholm and Hermansen (2004) suggested that the high content of unsaturated fatty acids might cause a bactericidal effect, which would benefit both protein digestion and metabolism.

Table 3.20. The input and output of N and P (LS-means ± SEM)[1]

Treatment	1	2	3	4	5	6	SEM	P-value
N input per kg gain, g	78.0 [a]	90.3 [c]	80.4 [a]	88.5 [c]	85.0 [b]	83.8 [b]	0.76	< 0.0001
N output per kg gain, g	50.0 [a]	62.3 [c]	52.4 [a]	60.5 [c]	57.0 [b]	55.8 [b]	0.76	< 0.0001
N efficiency, %	36.0 [a]	31.1 [c]	35.0 [a]	31.7 [c]	33.1 [b]	33.5 [b]	0.29	< 0.0001
P input per kg gain, g	10.0 [a]	11.1 [c]	10.1 [a]	10.8 [c]	10.6 [b]	10.5 [b]	0.09	< 0.0001
P output per kg gain, g	4.45 [a]	5.56 [c]	4.57 [a]	5.34 [c]	5.07 [b]	5.00 [b]	0.10	< 0.0001
P efficiency, %	55.5 [a]	49.9 [c]	54.9 [a]	50.9 [c]	52.3 [b]	52.6 [b]	0.46	< 0.0001

[abc,] *Figures within a row with different superscripts are significantly different.*
[1,] *After Strudsholm and Hermansen, 2004.*

Conclusions

- Pigs sired by Landrace boars
    - grow more efficiently
    - have leaner carcasses

  than pigs from Duroc sires.
- Entire male pigs
    - grew more efficiently
    - had reduced carcass lean
    - had reduced kill out yield

  when compared with gilts.
- Feeding grassmeal for all or part of the growth stage results in
    - depressed pig performance
    - reduced kill out yield
    - reduced back fat depth
- Compensatory growth was observed during a re-alimentation period following a period of feed restriction. However, where it did occur in most cases it was only partial.
- Adding 5% rapeseed oil instead of lard to the finisher diet increased
    - Nitrogen efficiency, and
    - Phosphorous efficiency

4. Effect of gender and slaughter weight

Three experiments were conducted to assess:

1. The effect of slaughter weight on pig performance and carcass quality of finishing pigs
2. Effect of gender and slaughter weight on production efficiency
3. Effect of gender and slaughter weight on
    a. pig performance and carcass quality
    b. carcass measurements
    c. Nitrogen (N) retention and excretion
    d. pigmeat eating quality
    e. skatole, androstenone and indole levels in backfat

4.1. Effect of slaughter weight on performance and carcass quality of finishing pigs

Introduction

Live-weight at slaughter has been increasing in Ireland for some time now and this trend is likely to continue. The objective of this experiment was to assess the effect of three target slaughter weights on the performance and carcass quality of finishing boars and gilts.

Materials and methods

Thirty six single sex groups (boars or gilts) of 13 pigs with a mean weight of 39.5 ± 3.3 kg were blocked on gender and weight and assigned at random to the following target live-weights at slaughter: (1) 85 kg, (2) 95 kg, and (3) 105 kg. Each treatment group was liquid fed (3.3 kg water / kg feed) 3 times daily using a computerised liquid feeding system (Big Dutchman, Vechta, Germany). Feed was offered to approximate *ad-libitum* intake. Diet 1 (13.7 MJ of DE / kg, 11.1 g/kg lysine) was offered for 28 days after which diet 2 (13.2 MJ of DE / kg, 9.6 g/kg lysine) was offered to slaughter. Pigs were marketed once weekly. Pigs within a group were selected for slaughter when they were within 5 kg of the target weight or within two weeks following the selection of the first pigs from the pen group.

Pigs were housed in a pre-fabricated finisher house with a central passage with 18 pens (4.02 m x 2.62 m). Pens had concrete pen divisions and the floors were fully slatted (concrete). Mechanical ventilation ensured that air temperature was controlled at 20-22 ^{o}C. Feeding was from a 4.0 m long semi-circular PVC trough (diameter 215 mm) with a 120 mm wide horizontal step 210 mm above slat level. Troughs were inspected daily one hour after the morning feed and feed allocation was adjusted upwards or downwards as required.

Data were analysed by PROC GLM for a 3 x 2 factorial design. The Duncan's multiple range test was used for means separation.

Results

The results of this trial are presented in Table 4.1.1. Days to slaughter increased incrementally with each increase in the target live-weight at slaughter ($P < 0.001$) as did live weight at slaughter ($P < 0.001$) and carcass weight ($P < 0.001$). Kill out yield was similar for pigs with a target slaughter weight of 95kg and 105kg and both were higher than for pigs slaughtered at 85kg ($P < 0.05$). Daily feed intake was higher for pigs with a target slaughter weight of 105kg than those with a target

slaughter weight of 85kg ($P < 0.05$). Fat depth was 10.9, 11.6, and 12.2 mm (SEM = 0.19; $P < 0.001$) and muscle depth was 55.0, 56.4, 58.6 mm (SEM = 0.70; $P < 0.01$) for target live-weights at slaughter of 85, 95 and 105kg, respectively.

Days to slaughter, kill out yield, carcass weight and daily feed intake was higher ($P < 0.05$) for gilts than boars. Fat depth was 11.6 and 11.6 mm (SEM = 0.15; $P > 0.05$), muscle depth was 57.7 and 55.6 mm (SEM = 0.57; $P < 0.01$) and carcass lean meat yield was 597 and 591 g/kg (SEM = 1.2; $P < 0.01$) for gilts and boars, respectively. Carcass daily gain was higher ($P < 0.05$), carcass FCR better ($P < 0.001$) and lean FCR better ($P < 0.05$) for boars than gilts, respectively. Feed costs were lower for boars than gilts on a per kg dead weight basis ($P < 0.01$) and on a per kg lean basis ($P < 0.05$).

Table 4.1.1. Effect of live weight at slaughter and gender on performance

	Target slaughter wt.			Gender		F-test
	85	**95**	**105**	**Gilt**	**Boar**	
Days to slaughter	62.0[a]	68.7[b]	78.3[c]	71.5	67.8	***
Live weight at slaughter, kg	90.0[a]	96.2[b]	103.2[c]	96.7	96.1	NS
Carcass weight, kg	68.0[a]	73.6[b]	79.2[c]	74.2	73.0	+
Kill out, g/kg	756[a]	765[b]	767[b]	767	759	*
Daily feed intake, g/day	2099[a]	2130[ab]	2154[b]	2162	2094	*
Carcass daily gain, g/day	680	700	684	679	696	*
Carcass FCR, g/g	3.08	3.05	3.16	2.70	2.51	***
Lean meat, g/kg	595	593	594	597	591	**
Lean daily gain, g/day	396	406	399	399	402	NS
Lean FCR, g/g	5.29	5.25	5.4	5.43	5.20	*
Feed cost per kg DW, c/kg	60.0	59.5	61.5	62.1	58.5	**
Feed cost per kg lean, c/kg	103.1	102.4	105.4	105.8	101.4	*

[abc] *values within rows with different subscripts are significantly different (P<0.05)*

[+] *P<0.1, * P<0.05, ** P<0.01, *** P<0.001, NS non significant.*

Conclusion

It is concluded that increasing slaughter weight from 85 to 105 kg live-weight does not affect pig daily gain, FCR, carcass lean meat yield or feed cost per kg dead-weight. However, fat depth and muscle depth did increase with increasing slaughter weight. Feed cost per kg dead-weight and per kg lean was higher for gilts than boars.

4.2. Effect of gender and slaughter weight on production efficiency

Introduction

Irish slaughter weights are lower than those of our E.U counterparts. The potential advantages of producing heavier pigs are widely recognized by the slaughter/processing industry. Castration would allow males be taken to heavier slaughter weights without the risk of boar taint. Feed conversion efficiency of boars is significantly better than for castrates (Squires et al., 1993). Boars generally grow faster than castrates when feed is restricted but with ad-libitum feeding the difference is less (MLC, 1989). The aim of this study was to examine the effect of gender and slaughter weight on production efficiency in modern lean pigs.

Materials and Methods

This trial was a 3 (gender) X 5 (slaughter weight) factorial design with 6 pens per treatment. The genders were boars (B), castrates (C) and gilts (G) and the target live-weights at slaughter were 80, 90, 100, 110 and 120kg. The experimental unit was 2 littermate pigs of the same sex reared in the one pen. All pigs were fed the same diets based on cereals and soyabean meal (Appendix 1). The duration of the experiment was from weaning at c. 28 days until the appropriate target live-weight at slaughter was reached. Statistical analysis was carried out using the GLM procedure of SAS (1996).

During the weaner stage, pairs of pigs were penned in fully slatted (plastic; Faroex, Manitoba, Canada) pens 1.2m * 0.9m. Each pen had a single stainless steel feeder 30 cm wide and feed was provided *ad-libitum*. Water was available *ad-libitum* from bowls (BALP, Charleville-Mezieres, Cedex, France). Temperature was maintained at 28-30^{o}C in the first week and reduced by 2^{o}C per week to 22^{o}C during week 4 post-weaning.

During the finisher stage pigs were penned in fully slatted pens (concrete slats, 75mm solid width 20mm slots), 1.81m * 1.18m with steel rail partitions. The house was mechanically ventilated and air temperature was maintained at 20 to 22 ^{0}C. Stainless steel dry feed hoppers 30 cm in length (O'Donovan Engineering, Coachford, Co. Cork) were used and feed was provided *ad-libitum* as dry pellets. Water was available ad libitum from one BALP drinking bowl.

Data were analysed by PROC GLM for a 3 x 5 factorial design. The Duncan's multiple range test was used for separation of gender means.

Results

Feed intake of castrates was higher than for boars and gilts (P<0.01). Gilts had lower growth rates (P<0.05) and took longer to reach slaughter weight (P<0.05) than either castrates or boars. Boars had a better FCR than either castrates or gilts (P<0.05). Castrates had a higher kill-out than boars with gilts being similar to both (P<0.05). Carcass lean meat yield and muscle depth were similar for boars, gilts and castrates (P>0.05), however castrates had greater backfat depth than either boars or gilts.

The sequential increase in slaughter weight caused a linear increase in days to slaughter (P<0.01), feed intake (P<0.01), daily gain (P<0.10), FCR (P<0.01), kill-out (P<0.01), muscle depth (P<0.01), and fat depth (P<0.01). There was a quadratic increase in carcass lean content as slaughter weight increased (P<0.01).

Table 4.2.1. Effect of gender on pig performance

Gender	Boar	Cast	Gilt	s.e.
Days	125.8[a]	124.0 [a]	132.5[b]	1.7
Feed/day, g	1705[a]	1878[b]	1746[a]	21
Daily gain, g	748[a]	756[a]	712[b]	15
FCR, g/g	2.28[a]	2.49[b]	2.46[b]	0.03
Kill out, g/kg	756 [a]	768[b]	762[ab]	3
Carcass lean, g/kg	579	582	591	0.6
Muscle, mm	55.9	57.8	58.0	1.1
Backfat, mm	12.2[a]	13.5[b]	12.4[a]	0.4

[abc] *Different superscripts across rows indicate significant differences (Duncans MRT, P<0.05)*

Table 4.2.2. Effect of slaughter weight on pig performance

Slaughter weight., kg	80	90	100	110	120	s.e.	Lin[1]	Quad[1]
Days	105.6	116.8	127.2	140.3	147.3	2.4	**	NS
Feed/day, g	1602	1746	1810	1818	1904	30	**	+
Daily gain, g	715	737	756	737	748	15	+	NS
FCR, g/g	2.24	2.39	2.41	2.48	2.55	0.04	**	NS
Kill out, g/kg	754	761	761	769	766	4	**	NS
Carcass lean, g/kg	579	587	584	589	559	0.8	P=0.11	*
Muscle, mm	51.6	55.3	58.1	62.2	56.9	1.5	**	**
Backfat, mm	11.1	11.9	12.9	13.8	13.1	0.5	**	+

[1] ***Linear and quadratic effects; + = P<0.10; * = P<0.05; ** = P<0.01***

Conclusions

Castrates ate more feed per day than boars but had poorer feed conversion efficiency. Differences between genders in carcass traits were small apart from backfat depth, which was greatest in castrates. Castrates also had a higher kill out yield than boars. Daily feed intake increased with increasing slaughter weight and feed conversion efficiency deteriorated. Carcass lean meat content increased up to 90kg live weight then reached a plateau and declined after 110kg live weight.

4.3. Effect of gender and slaughter weight on pig performance and carcass quality

Introduction

The carcass weight of Irish pigs has, for economic reasons, increased steadily in recent years. If this trend continues producers may have to re-introduce castration of male pigs to help prevent the development of boar taint in the meat. The aim was to examine the effect of gender and slaughter weight on performance and carcass quality in pigs of a lean genotype.

Materials and methods

Forty five same gender pairs of pigs (Meatline Landrace sire on Landrace x Large White sows) were used in a 3 (gender) x 3 (slaughter weight) factorial design with 5 pairs per treatment. The experimental period was from weaning (mean = 26 days and 8.6kg) to slaughter. Gender was boar, castrate and gilt and the target slaughter weights were 80, 100 and 120kg liveweight. All pigs were fed the same diets based on wheat, barley and soybean meal ad libitum as dry pellets. Diet composition and nutrient composition is presented in Appendix 1.

Housing of pigs was as described in Section 4.2. Data were analysed by PROC GLM for a 3 x 3 factorial design. The Duncan's multiple range test was used for means separation.

Results and Discussion

Gender x slaughter weight interaction effects were not significant ($P>0.05$).

Daily feed intake was higher for castrates than either boars or gilts ($P<0.01$) (Table 4.3.1). Daily gain was higher for castrates than gilts, which were both similar to that of boars ($P<0.01$). Feed conversion ratio (FCR) was better for boars than either castrates or gilts, which were similar ($P<0.05$). Backfat depth, muscle depth and carcass lean meat content (by Hennessy Grading Probe) were 11.0, 13.3 and 11.2mm (s.e. 0.4; $P<0.01$); 51.2, 52.3 and 53.6mm (s.e. 1.1; NS) and 563, 544 and 567g/kg (s.e. 0.39, $P<0.01$) for boars, castrates and gilts respectively.

Daily feed intake increased with each increase in slaughter weight ($P<0.05$) (Table 4.3.2.). Daily gain increased with slaughter weight ($P<0.05$) and FCR deteriorated with each sequential increase in weight at slaughter ($P<0.05$). Backfat depth, muscle depth and carcass lean meat content were 10.2, 12.2 and 13.1mm (s.e. 0.4; $P<0.01$); 46.2, 53.2 and 57.7mm (s.e. 1.1; $P<0.01$) and 568, 557 and 549g/kg (s.e. 4; $P<0.01$) respectively.

Table 4.3.1. The effect of gender on pig performance and carcass quality

Gender	Boar	Castrate	Gilt	SE	F-test
Weaning weight, kg	8.4	8.7	8.7	0.17	NS
Weaning to slaughter, d	128[ab]	124[a]	131[b]	1.8	*
Daily feed intake, g/day	1687[a]	1847[b]	1744[a]	21.0	**
Daily gain, g/day	737[ab]	753[b]	710[a]	9.6	**
Feed conversion ratio, g/g	2.30[a]	2.45[b]	2.47[b]	0.043	*
Slaughter weight, kg	102.5	102.1	100.9	0.58	NS
Carcass lean meat, g/kg	563[a]	544[b]	567[a]	0.39	**

[abc] *Means with different subscripts within rows are significantly different (P<0.05).*

Table 4.3.2. The effect of slaughter weight on pig performance and carcass quality

Slaughter weight, kg	80	100	120	SE	F-test
Weaning weight, kg	8.4	8.8	8.6	0.17	NS
Weaning to slaughter, d	105[a]	128[b]	150[c]	1.8	**
Daily feed intake, g/day	1541[a]	1772[b]	1965[c]	21.0	**
Daily gain, g/day	717[a]	735[ab]	748[b]	9.6	*
Feed conversion ratio, g/g	2.15[a]	2.43[b]	2.64[c]	0.043	**
Slaughter weight, kg	83.9[a]	102.0[b]	119.7[c]	0.58	**
Carcass lean meat, g/kg	568[a]	557[ab]	549[b]	0.39	**

[abc] *Means with different subscripts within rows are significantly different (P<0.05).*

Conclusion

Even using modern genotypes (highly selected for lean tissue growth rate) boars still grow more efficiently and will thus be more profitable than castrates.

Increasing slaughter weight will reduce the lean meat content in the carcass and cause FCR to deteriorate. However, heavier pigs may still be more profitable since non-feed and sow feed costs per pig are spread over a greater carcass weight. Producers will thus continue to increase pig weight at slaughter up to the maximum permissible. This trend will increase the incidence of boar taint but could be mitigated by the re-introduction of castration at these heavier weights.

4.4. Effect of gender and slaughter weight in pigs on carcass measurements

Introduction

The economic advantages of producing heavy pigs are widely recognised by producers and processors alike (Lawlor, 2003). Castration would allow male pigs to be brought to heavier weights at slaughter without the risk of boar taint. The aim was to examine the effect of gender and slaughter weight on carcass measurements in pigs of a lean genotype.

Material and methods

The carcasses used in the present study were from the same pigs as described in Section 4.3.

Results and Discussion

Gender x slaughter weight interaction effects were not significant (P>0.05). Carcass length was greater (P<0.05) for boars than castrates and gilts, which were similar (Table 4.4.1.) Leg length, ham circumference, weight of cold carcass, weight of hind leg and shoulder weight was not different for boars, castrates or gilts (P>0.05). Castrates had heavier loins (P<0.01) and bellies (P<0.05) than either boars or gilts, which were similar. There was a tendency for the 4 primal cuts as a percentage of side weight to be higher for castrates than boars (P<0.11). The loin as a percentage of the side weight was 16.5, 18.2 and 17.1 (s.e. 0.35 %; P<0.01) for boars, castrates and gilts, respectively.

Carcass length, leg length, ham circumference, weight of cold carcass, weight of hind leg, shoulder weight, loin weight and weight of belly all increased with each sequential increase in slaughter weight (P<0.01) (Table 4.4.2.). The weight of the 4 primal cuts, as a percentage of the side weight, was not affected by weight at slaughter (P>0.05).

Table 4.4.1. The effect of gender on pig performance and carcass quality

Gender	Boar	Castrate	Gilt	SE	F-test
Carcass length, mm	845[a]	832[b]	836[b]	3.3	*
Leg length, mm	388	383	383	2.5	NS
Ham circumference, mm	712	720	719	3.4	NS
Cold carcass weight, kg	77.7	78.6	77.4	0.74	NS
Weight of primal cuts, kg					
Hind leg	9.30	9.73	9.59	0.153	NS
Shoulder	5.48	5.56	5.40	0.096	NS
Loin	6.39[a]	7.71[b]	6.59[a]	0.159	**
Belly	3.46[a]	3.67[b]	3.47[a]	0.061	*
Four primal cuts as % of side weight	63.7	66.6	65.1	0.91	NS

[abc] *Means with different subscripts within rows are significantly different (P<0.05).*

Table 4.4.2. The effect of slaughter weight on pig performance and carcass quality

Slaughter weight, kg	80	100	120	SE	F-test
Carcass length, mm	793[a]	837[b]	884[c]	3.3	**
Leg length, mm	364[a]	385[b]	405[c]	2.5	**
Ham circumference, mm	672[a]	720[b]	760[c]	3.4	**
Cold carcass weight, kg	63.1[a]	78.6[b]	91.8[c]	0.74	**
Weight of primal cuts, kg					
Hind leg	7.88[a]	9.54[b]	11.2[c]	0.153	**
Shoulder	4.56[a]	5.45[b]	6.41[c]	0.096	**
Loin	5.40[a]	6.64[b]	8.10[c]	0.159	**
Belly	2.84[a]	3.56[b]	4.19[c]	0.061	**
Four primal cuts as % of side weight	65.9	64.2	65.4	0.91	NS

[abc] *Means with different subscripts within rows are significantly different (P<0.05).*

Conclusion

This work indicates that the processing value of carcasses from castrates is higher than that for boars. Heavier carcasses yield more product for approximately the same slaughtering cost and the associated larger muscles will make it easier to use seam butchery techniques that result in lean, well-trimmed, attractive cuts and joints.

4.5. Effect of gender and slaughter weight on Nitrogen (N) retention and excretion

Introduction

The carcass weight of Irish pigs has increased steadily in recent years. If this trend continues producers may have to re-introduce castration of male pigs to help prevent the development of boar taint (Lawlor, 2003). The aim of this study was to examine the effect of gender and slaughter weight on N intake, retention and excretion.

Materials and methods

The data used in the present study were from the pigs described in Section 4.3. Crude protein contents of the diets fed were 223g/kg in the starter diet (1kg/pig); 209g/kg in the link diet (5 kg/pig); 197g/kg in the weaner diet (to day 42 post-weaning); 182g/kg in the first stage finisher diet (day 42 to day 84 post weaning): 157g/kg in the second finisher diet (day 84 to slaughter). Diet ingredient composition and nutrient content is presented in Appendix 1.

Blood, organs and a flushed gastro-intestinal tract (GIT) were collected at slaughter, weighed and frozen. The left carcass side was weighed post slaughter and dissected into its primal cuts. The primal cuts were dissected into their bone and soft tissue fractions. Blood, organs and GIT, carcass soft tissue and bone were then ground, homogenised and sampled. The N content of each was determined using the Kjeldahl procedure (AOAC, 1990) using a Kjeltec apparatus. Using these data the N content of each pig at slaughter was determined. The N content of pigs at weaning (g/pig) was estimated as follows: (weaning weight (kg) x 28) where 28 approximated the N content in grammes per kg live weight. N intake, retention and excretion per pig was then calculated. Data were analysed by PROC GLM for a 3 x 3 factorial design. The Duncan's new multiple range test was used for means separation.

Results

There was no gender x slaughter weight interaction for N intake ($P>0.05$), N retention ($P>0.05$) or N excretion ($P>0.05$). Intake, retention and excretion values for N are shown in Table 4.5.1 for each slaughter weight group and gender.

Each slaughter weight group differed from the other two for N intake per pig, N retention per pig, N excretion per pig and N excretion per kg carcass and per kg lean ($P<0.01$). Pigs in the heavier slaughter weight group consumed more N and retained more ($P<0.01$). They also excreted more total N and more N per kg carcass and per kg lean ($P<0.01$). The percentage of feed N retained was similar for pigs slaughtered at 100 and 120 kg live weight, which was lower than that for pigs

slaughtered at 80kg.

Intake of N was similar for all genders. Boars retained more N per pig (P<0.01) and a greater percentage of feed N (P<0.001) than did gilts or castrates. Boars excreted less N per pig P<0.05), per kg carcass P<0.05) and per kg lean P<0.05) than gilts or castrates (P<0.05).

Table 4.5.1. N balance weaning to slaughter by weight group and by gender.

	Slaughter weight			F-test	Gender			F-test
	80	100	120		Boar	Castrate	Gilt	
Initial carcass N, g/pig	235	246	242	NS	235	244	244	NS
N intake, g/pig	4646[a]	6160[b]	7746[c]	***	5952	6303	6295	NS
N retention[1], g/pig	1838[a]	2178[b]	2610[c]	***	2286[a]	2144[b]	2197[b]	**
N retention[1] %	39.5[a]	35.5[b]	33.9[b]	***	39.2[a]	34.1[b]	35.6[b]	***
N excretion[1], g/pig	2826[a]	4017[b]	5134[c]	***	3665[a]	4196[b]	4116[b]	**
N excretion per kg carcass, g	45.0[a]	51.2[b]	56.4[c]	***	46.8[a]	53.0[b]	52.8[b]	**
N excretion per kg lean	79.5[a]	92.6[b]	103.1[c]	***	83.4[a]	97.9[b]	93.8[b]	**

[1] *Includes organs and blood*

Discussion

Feed conversion efficiency from weaning to sale was 2.15, 2.43 and 2.64 (s.e. 0.043; P<0.01) for pigs slaughtered at 80, 100 and 120kg respectively. The 0.49 deterioration in FCR as slaughter weight increased from 80 to 120 kg caused an increase in N excretion of 82% per pig, 25% per kg carcass or 30% per kg lean. It is evident from this that as the pig gets heavier, low protein diets should be fed to reduce N excretion. Tokach et al., (1999) stated that multiphase feeding could reduce N excretion by up to 15% compared with two-phase feeding.

Entire male pigs require less feed and have a better FCR than castrates and so the output of N in manure is less than with castrates (Desmoulin et al, 1974). According to Coffey (1996) an improvement in FCR of 0.25 could result in a reduction of 5-10% in the quantity of N excreted by a pig. However, castration in the present study caused a 0.15 deterioration in FCR which resulted in a 14.5% increase in N excretion. Feed conversion efficiency from weaning to sale was 2.30, 2.45 and 2.47 (s.e. 0.043; P<0.05) for boars, gilts and castrates, respectively. The concentration of protein in diets for castrates and gilts could be reduced relative to boars to reduce N excretion. This would also improve their efficiency of production (Redshaw, 1996).

Conclusion

As slaughter weight increased so too did N intake and even though N retention also increases, N excretion increased with each increment in weight. Should castration be re-introduced to mitigate against the likely increase in the incidence of boar taint due to increasing slaughter weights then N excretion will increase. Diets for castrates and gilts with lower protein concentrations relative to

those of boars should be fed.

4.6. Effect of slaughter weight and gender on pigmeat eating quality

Introduction

Very lean genotypes have low levels of intramuscular fat and this has been blamed for pork from lean pigs being dry and tough. The objective of this trial was to investigate the effect of gender (boar, castrate, gilt) and slaughter weight on eating quality of pork

Materials and Methods

The experiment involved 36 pigs from sireline (HiLean Landrace) mated to F1 (Landrace x Large White) sows as in Experiment 1. Six pigs (4 male and 2 female) were selected at birth from each of six litters. Two male pigs were surgically castrated at c. 4 days of age. Pigs were weaned at 24-28 days of age, weighed individually and tagged. All pigs of one gender were placed in a single pen. Half from each gender group (pigs selected at random) were slaughtered at c. 90kg and half at c. 105kg.

Treatments were as follows:

- Entire males slaughtered at c. 90kg liveweight
- Entire males slaughtered at c. 105kg liveweight
- Castrated males slaughtered at c. 90kg liveweight
- Castrated males slaughtered at c. 105kg liveweight
- Females slaughtered at c. 90kg liveweight
- Females slaughtered at c. 105kg liveweight

The pigs were fed diets based on barley, wheat and soyabean meal as dry pellets and feeding was ad libitum. Dietary ingredients and chemical composition is shown in Appendix 1. Pigs were transported to the slaughter plant, rested for two hours, stunned using carbon dioxide and slaughtered. Carcasses were chilled for c. 18 hours.

pH measurements were made in the longissimus dorsi muscle between the 3rd and 4th last rib about 45 minutes (pH45) and 24 hours (pH24) post mortem using a WTW 325 pH meter (Weilheim, Germany) and a WTW spear probe (Joe Walsh Scientific, 12 Glendoher Avenue, Rathfarnham, Dublin 16). The **carcass temperature** was also measured between the 3rd and 4th last rib at these times using a WTW TFK150/HC temperature sensor.

The **lean meat content** was estimated by the Hennessy Grading Probe (Hennessy and Chong,

Auckland, New Zealand) 6cm from the midline at the 3/4th last rib, according to the following formula:

Estimated lean meat content (g/kg) = 534.1 –7.86X_1 + 2.66X_2

where *X_1 and X_2* represent *backfat (mm) and muscle (mm)*depths respectively

The **hot carcass weight** was also recorded at 45 minutes after slaughter.

Following chilling at 2±1^{o}C for 24 hours the **pH24 and temperature** were recorded in the longissimus dorsi between the 3rd and 4th last rib, while the carcasses were still suspended from the gambrels.

The carcass was jointed using commercial cutting techniques and the L. dorsi was dissected out using a knife making sure to remove all subcutaneous and intermuscular fat. The samples of longissimus dorsi were transported to the process hall in University College, Cork for assessment of eating quality.

The L. dorsi was divided into 8 chops (2cm thick) cut perpendicular to the muscle fibre direction. Chop samples for drip loss, cooking loss, shear force and sensory analysis were vacuum packed and stored at 4^{o}C. Samples for intramuscular fat determination were vacuum packed and frozen at -20^{o}C until preparation for analysis.

Muscle colour was measured at day 1 post mortem on 2cm thick chops of longissimus dorsi, placed on red plastic cutter boards, overwrapped with commercial polyvinyl chloride shrink film and allowed to bloom at 10^{o}C for 1 hour. Muscle colour was assessed objectively using a Minolta CR-300 Colorimeter (Minolta Camera Co., Osaka, Japan) using Hunter L*, a*, b*, scale. The instrument was calibrated using a white tile.

To determine the percentage **drip loss,** two chops were taken at day 1 post mortem and cut into cubes of similar size (c. 100g excluding all external fat and connective tissue) and weighed, with these weights recorded. They were suspended in an expanded but sealed bag, so that meat did not come in contact with the bag. The samples were suspended in darkness at 4^{o}C and removed after 24hours, when the surface was blotted with tissue and the steaks were re-weighed (Honickel and Hamm, 1994).

Percentage **cooking loss** was determined on day 2 post mortem. Samples were weighed and placed in plastic bags. The bags containing the meat were then placed in a water bath at 80^{o}C and the chop was cooked until an internal cooking temperature of 75^{o}C was reached (approx. 45 minutes), the samples were dried with paper towel to remove excess moisture and weighed to determine cooking loss. The cooking loss was expressed as a percentage of the original weight of the chop. The samples used for cooking loss determination were then chilled at 4^{o}C. Following chilling, each sample was cut, parallel to the muscle fibres, into replicate cores of 12mm^2 cross-sectional area. Cores that contained connective tissue or were not considered acceptable due to shape were discarded. **Tenderness** was measured using a Warner-Bratzler shear force blade fitted to an Instron Universal Testing Machine. A 25kg load cell was used. Instron tenderness was expressed, as the pressure needed to compress a cooked loin sample. Less pressure means a more tender sample. Six replicates were conducted per sample

For **intramuscular fat** (marbling or lipid content) a 4cm chop sample from the L. dorsi was passed through plates with holes of 4mm diameter (Moulinex, HV3ADRB) and homogenised for 5 minutes using a Kenwood (FP370) processor. Extractable lipid and moisture content were estimated using the AOAC (1995) rapid microwave – solvent extraction procedure.

On day 2 post mortem, a semi-trained panel comprised of 3 males and 3 females in their early twenties was used to evaluate **palatability**. The chops were cooked under a grill and turned regularly until an internal temperature of 75^{o}C. Following the removal of all connective tissue, chop centers were cut into pieces 2cm x 2cm. Samples were served on plates labelled with three digit random numbers. Cooked samples were evaluated for tenderness, juiciness and overall flavour using an eight-point scale (1=extremely desirable and 8=extremly undesirable for each trait). Panellists were presented with distilled water for rinsing the mouth between samples.

Results

The effect of slaughter weight on carcass temperature, pH and colour is shown in Table 4.6.1. Carcass pH of the 90kg pigs was lower at 45 minutes and 24 hours after slaughter ($P<0.05$). Differences in intramuscular fat and in eating quality were not significant.

The effect of gender on carcass temperature, pH and colour is shown in Table 4.6.2. Differences were not significant ($P<0.05$) apart from carcass temperature at 24 hours ($P<0.01$) and

intramuscular fat content.

Table 4.6.1. Pork quality measures by slaughter weight group

	90	105	s.e.	F-test
Carcass temperature				
45 minutes	34.1	34.7	1.03	68
24 hours	0.96	1.82	0.21	**
Carcass pH				
45 minutes	6.44	6.21	0.64	2 *
24 hours	5.72	5.58	0.037	1*
Meat colour				
L	48.8	50.3	0.65	10
A	1.38	2.11	0.25	5 +
B	4.9	5.69	0.21	**
Meat traits				
Drip loss, %	2.01	2.78	0.284	7 +
Intramuscular fat, g/kg	1.17	1.38	0.075	5 +
Eating quality				
Tenderness	4.52	4.59	0.18	77
Juiciness	4.56	4.56	0.14	99
Flavour	5.51	5.38	0.1	37

Table 4.6.2. Pork quality attributes by sex

	Boar	Castrate	Gilt	s.e.	F-test
Carcass temperature					
45 minutes	34.9	35.8	35.9	0.67	52
24 hours	0.9^{a}	1.6^{b}	1.8^{b}	0.25	**
Carcass pH					
45 minutes	6.31	6.38	6.29	0.79	72
24 hours	5.62	5.68	5.65	0.45	64
Meat colour					
L	49.1	49.7	49.7	0.79	83
A	2.13	1.52	1.58	0.31	33
B	5.27	5.25	5.35	0.25	96
Meat traits					
Drip loss, %	2.78	1.95	2.47	0.35	26
Intramuscular fat, g/kg	1.09^{a}	1.65^{b}	1.08^{a}	0.09	**
Eating quality					
Tenderness	4.56	4.51	4.6	0.23	97
Juiciness	4.37	4.8	4.53	0.18	26
Flavour	5.5	5.51	5.33	0.12	47

Discussion

Although our results show that slaughter weight had little effect on intramuscular fat content or shear force values, there was a tendency for intramuscular fat content to increase and shear force values to improve with increasing slaughter weight. However, the improvement in shear force was less than 1kg. Generally differences in shear force of less than 1kg are considered to have little significance since this difference cannot readily be detected by a trained taste panel.

These results suggest that the absolute levels of marbling may now be below the threshold at which consumers can detect differences in eating quality. This was probably the case in this experiment as intramuscular fat values were only 1.17% and 1.38% on average for pigs slaughtered at 90kg and 105kg respectively. Bejerholm and Barton-Gade (1986) suggested that the intramuscular fat content of pork had to be greater than 2% before any noticeable effects on sensory attributes could be detected. De Vol (1988) similarly concluded that a threshold level of 2.5-3.0% was necessary to attain an acceptable level of tenderness in roasted chops.

Also, our results indicate that pigs slaughtered at 105kg had higher carcass temperatures (recorded 24hours post slaughter) than pigs slaughtered at 90kg. The development of PSE is temperature dependent and high muscle temperatures can also escalate this problem (Fernandez et al. 1994; McCaw, 1994). A possible reason for the higher carcass temperature in the 105kg slaughter group is that muscle cooling rates are slower in heavier carcasses. Therefore, muscle temperature remains higher for longer in the early post mortem period allowing a higher level of glycolosis leading to a possible increase in the incidence of PSE meat.

4.7. Effect of slaughter weight on skatole, androstenone and indole levels in backfat.

Introduction

Boar taint presents itself as a distinct unpleasant perspiration-like, faecal-like, or urine-like smell, when fat or meat from some entire mature boars is heated. Taint is rarely detected in meat from gilts, castrated boars, or sexually immature boars (Babol et al., 2002). Castration of male pigs has been practiced for centuries to avoid the occurance of boar taint. EU regulations (Council Directive 91/497/EEC, 1991) prohibit the sale of meat from entire male pigs of 80kg carcass weight (excluding head and limbs) or over unless an inspector has tested the meat for pronounced sexual odours and declared it not to have such odours. If the meat has been found to have such odours, it must be treated in accordance with the procedures laid down in Council Directive 77/99/EEC (i.e. heating, salting or drying).

Skatole (3-methyl-indole) and androstenone (5α–androst-16-ene-3-one) are believed to be the two main contributors to boar taint (Bonneau et al, 1993). Skatole is produced in the digestive tract by microbial breakdown of tryptophan, metabolised in the liver, partially excreted with the urine and partially deposited in the fatty tissue (Agegaard and Laue, 1993). It produces a faecal-like odour and a bitter taste (Hansson et al, 1980) and is preferentially deposited in the fatty tissue (Claus et al, 1994). The androstenones are steroids belonging to the family of C_{19}-Δ^{16}-steroids. Androstenone, identified by Patterson (1968), is primarily synthesized in boar testes (Grower, 1972; Brooks and Pearson, 1986) and transported via the bloodstream to the salivary gland where it is bound to a specific binding protein (Booth, 1984). After release into the saliva it acts as a pheromone (Booth and Signoret, 1992). Androstenones are found only in the fat (Claus et al, 1994). The androstenones have a urine-like or perspiration-like odour. Another compound that has been suggested to contribute to boar taint is indole (another typtophan derivative) (Moss et al, 1993).

The objective of this study was to determine the effect of liveweight at slaughter on skatole, androstenone and indole levels in the backfat of entire male pigs.

Materials and methods

The animals used in this study and their feeding and management regimen has already been described in Section 4.3. Eighty grammes of backfat (taken between the 3rd and 4th last rib was taken from the carcasses of 24 boars, 24 gilts and 24 castrates. Within each sex group 8 pigs had been slaughtered at 80kg, 8 at 100kg and 8 at 120kg).

The fat was analysed for skatole, androstenone and indole at the Danish Meat Research Institute, Roskilde, Denmark using the high-performance liquid chromatographic method described by Hansen-Moller (1994). The 24 samples of boar fat were analysed separately while 1 composite sample (10g from each of 8 pigs) for each of the 3 slaughter weight groups was analysed for both the castrates and gilts. The results for each compound are expressed in ppm.

Results and Discussion

Skatole, androstenone and indole levels in the backfat were higher for entire males than either castrates or gilts. The levels of skatole and androstenone in castrates and gilts were below the levels detectable by a trained sensory panel. According to Bonneau and Prunier (2005) the cut off levels are 0.20 to 0.25ppm and 0.5 to 1.0ppm for skatole and androstenone, respectively.

With entire males skatole levels increased between 80 and 100kg and then dropped at 120kg. Androstenone concentration in the backfat of entire males increased with each sequential increase in slaughter weight. Conversely, the indole concentration in the backfat of entire males dropped with each sequential increase in slaughter weight. Androstenone levels were above the cut off levels for detection by a trained sensory panel at each of the weight categories examined. Skatole levels were only above the cut off point for detection by a trained sensory panel (Bonneau and Prunier, 2005) for entire males slaughtered at 100kg. However skatole levels can be manipulated by diet (Hansen et al., 2005) and management (Allen et al., 2001) and may not be as important as androstenone which is to a large extent genetically determined having very high estimates for heritability ranging from 0.25 to 0.87 (Bonneau and Prunier, 2005).

It is interesting to note that the cut off levels for both skatole and androstenone for detection by a trained sensory panel were estimated using panels in continental Europe and Scandinavia where castration of male pigs is the norm. For this reason consumer sensitivity to boar taint may be higher than that in Ireland and the United Kingdon where the production of pork from entire male pigs has been almost exclusively practiced since the 70's. The incidence of boars with a taint detectible by trained sensitive consumers was found to be as low as 8% in Ireland (Allen *et al.*, 2001). For this reason the cut off level of 0.5 to 1.0ppm for androstenone may greatly overestimate the likelihood of boar taint being detected by Irish consumers. However we must remember that c.40% of Irish pigmeat is exported to countries where consumers might be more sensitive to boar taint. In addition, even among Irish consumers where the frequency of boar taint is relatively low, market share for pigmeat is likely to have been lost due to the presence of a small percentage of sensitive

consumers.

Table 4.7.1. Effect of liveweight at slaughter on skatole, androstenone and indole levels in the backfat of entire male pigs.

Live weight at Slaughter, kg	Compound		
	Skatole (ppm)	Androstenone (ppm)	Indole (ppm)
80	0.16	0.61	0.26
100	0.33	1.04	0.11
120	0.18	1.14	0.05

Table 4.7.2. Effect of liveweight at slaughter on skatole, androstenone and indole levels in the backfat of castrates.

Live weight at Slaughter, kg	Compound		
	Skatole (ppm)	Androstenone (ppm)	Indole (ppm)
80	0.05	<0.20	<0.03
100	0.02	0.33	<0.03
120	0.09	<0.20	<0.03

Table 4.7.3. Effect of liveweight at slaughter on skatole, androstenone and indole levels in the backfat of gilts.

Live weight at Slaughter, kg	Compound		
	Skatole (ppm)	Androstenone (ppm)	Indole (ppm)
80	<0.03	0.25	<0.03
100	0.02	<0.20	<0.03
120	0.05	<0.20	<0.03

Conclusions

The concentration of compounds (skatole, androstenone and indole) thought to be responsible for the expression of taint was below threshold levels for detection by trained sensory panels in both castrates and gilts at weights up to 120kg liveweight. Entire male pigs had androstenone levels in excess of those detectible by trained sensory panels at all liveweights weights from 80 to 120kg. The sensitivity of Irish consumers to boar taint would appear to be lower than that of other European consumers with the exception, perhaps, of the British. However, as we export a considerable proportion of pigmeat produced in Ireland we must endeavor to minimize its occurrence, so that market share is maintained. The trend towards increasing slaughter weight in Ireland must for this reason be considered carefully due to its link with the increase in compounds

responsible for boar taint and in particular androstenone. Castration of pigs is likely to be banned for animal welfare reasons by the EC in the near future and should not be considered as along term remedy for boar taint. There is a need for further EC wide research into the nutritional, management and genetic factors that could be exploited to allow the production of taint free pigmeat from entire male pigs.

5. Conclusions

- Diluting the diet with grass-meal reduced growth rate, caused a deterioration in feed conversion efficiency, reduced back fat thickness, reduced eye muscle thickness and reduced kill out yield compared to the conventional feeding regimen.
- Compensatory growth was observed during a re-alimentation period following a period of diet dilution with grass-meal. However, where it did occur in most cases it was only partial.

- Adding 5% rapeseed oil instead of lard to the finisher diet increased Nitrogen utilisation, and Phosphorous utilisation.
- Castrates had a higher kill out yield than boars.
- Nitrogen excretion from castrates was similar to gilts which were both higher than that from boars.
- The processing value of carcasses from castrates may be higher than that of boars and gilts.
- Carcasses from castrates and gilts were found to have a higher temperature (recorded 24 hours post slaughter) than boars. However, pH_{24} was not affected by gender.
- The intramuscular fat content of castrates was higher than that of boars or gilts, however at 1.65% this was well below the level (2.0%) above which any noticeable sensory attributes might be detected.
- Feed intake increased with increasing slaughter weight and feed conversion efficiency deteriorated.
- N excretion also increased with each increment in weight.
- Carcass lean content increased up to 90kg live weight then reached a plateau and declined after 110kg live weight.
- Heavier carcasses yielded more product for approximately the same slaughtering cost and the associated larger muscles could make it easier to use seam butchery techniques that result in lean, well-trimmed, attractive cuts and joints.
- The pH_{45} and pH_{24} were reduced with increasing slaughter weight and drip loss increased.
- It could be concluded that heavier pigs are more prone to the development of PSE than lighter pigs as their carcass temperature remains higher for longer than that of lighter pigs.
- The concentration skatole, androstenone and indole thought to be responsible for the expression of taint was below threshold levels for detection by trained sensory panels in both castrates and gilts at weights up to 120kg liveweight.
- Entire male pigs had androstenone levels in excess of those detectible by trained sensory panels at all liveweights weights from 80 to 120kg.

- Castration of pigs is likely to be banned for animal welfare reasons by the EC in the near future and should not be considered as along term remedy for boar taint.
- There is a need for further EC wide research into the nutritional, management and genetic factors that could be exploited to allow the production of taint free pigmeat from entire male pigs.

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Appendix1

Table 1. Ingredient composition and nutrient content of diets used in section 4 (g/kg)

	Weaner	***Finisher***	***Finisher heavy***
Barley	225	350	830
Wheat	355.4	404	0
Maize	100	0	0
Soya Full Fat	100	0	0
Soya Hi-Pro	180	215	140
Fat Tallow/Lard	10	10	10
L- Lysine HCl	4.0	2.5	3.0
DL-Methionine	2.0	0.7	0.4
L-Threonine	1.5	0.7	1.0
Di Cal Phos	5	0	0
Limestone Flour	11	13	11.5
Salt	3.0	3.0	3.0
Vit-Mins	3	1.0	1.0
Phytase 5000 iu/g	0.1	0.1	0.1
Nutrient composition, g/kg			
Dry matter	872	870	871
Crude Protein	191	183	145
Fat	46	27	31
Crude fibre	34	37	40
Ash	49	44	41
DE, MJ/kg	**14.1**	**13.7**	**13.2**
NE MJ/kg (CVB)	9.8	9.4	9.2
Lysine	**13.0**	**11.1**	**9.6**
Calcium	7.4	7.0	6.3
Phosphorous	4.9	4.0	3.9
Digestible phosphorous	3.3	2.5	2.4

Phytase: Natuphos – BASF; 5000 FTU/gm equal to 500 FTU per kg finished feed.