FEEDING PROTEIN DEFICIENT DIETS DURING THE GROWER PHASE INCREASES INTRAMUSCULAR FAT DEPOSITION AND IMPROVES EATING QUALITY OF PORK

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Background

The Australian pork industry has implemented significant changes to its production systems to produce leaner and 'healthier' pork. This has seen the introduction of leaner genetic lines, improved feed formulations, and the use of metabolic modifiers to improve carcass leanness. The gains in 'carcass leanness' have resulted in reduced intramuscular fat (IM fat) levels or marbling, and the perception is that pork is now tougher, less moist and has reduced flavour. Recent studies have shown that IM fat levels in male and female pigs are as low as 1% in some genotypes while in others, levels can vary between <1% to 4% (Channon *et al*., 2001).

Cisneros *et al*. (1996) investigated the use of nutrition to improve the quality of pork and reported that reducing the protein to energy ratio of the finisher phase increased IM fat deposition, but was also associated with a corresponding increase in carcass fat and decreased feed conversion. However, results from a recent pilot experiment (D'Souza *et al*., 2003) indicated that feeding individually housed pigs grower diets with 15% reduced protein to energy ratio, and grower and finisher diets restricted in Vit A improved the IM fat levels in the *Longissimus* muscle from 1.3% to 2%. Also, the improvements in IM fat did not negatively affect the subcutaneous fat levels of the pigs. The highest IM fat levels (2.7%) were obtained when pigs were fed a 30% reduced protein to energy ratio diet. However, this increase was accompanied by a negative impact on growth performance and increased subcutaneous fat.

Objectives

The objectives of this experiment was to (i) determine if feeding pigs either a grower diet with 15% reduced protein to energy ratio, or grower and finisher diets restricted in Vit A increased IM fat in pigs under commercial conditions without affecting growth performance and carcass quality, and (ii) to determine if nutritionally increased IM fat in pigs resulted in improved eating quality of pork.

Methods

A total of 63 Large White x Landrace x Duroc crossbred female pigs of similar age were used in this experiment. At approximately 14-16 days of age the pigs were transported to the Department of Agriculture, WA, Research Unit, Medina, and group housed in an environmentally controlled weaner room for three weeks (15-20kg LW), after which they were moved to a naturally ventilated experimental grower/finisher shed. The pigs were group-housed (7 pigs per pen). The pigs were stratified on a weight basis and randomly allocated to one of the 3 diet treatments. The dietary treatments were (i) Control (commercial grower and finisher diets), (ii) 15% reduced protein to energy ratio during the grower growth phase (commercial diet during the finisher growth phase), and (iii) Vit A restricted diet during the grower and finisher growth phase (commercial finisher diet without any added Vit A). All pigs had *ad libitum* access to feed, and water via nipple drinkers. At 23 weeks of age, the pigs were transported to a commercial abattoir and slaughtered according to standard commercial procedures.

Carcass weight and depth of backfat (Hennessy probe) were measured on the hot carcass as per commercial practice. Intramuscular fat in the *Longissimus thoracis* was chemically determined using the method of direct soxhlet extraction of fat by a solvent (hexane) and expressed as the weight percentage of wet muscle tissue (AOAC, 1990). The pH of the *Longissimus thoracis* muscle between the 12th and 13th rib was determined at 24h (pH_u) post-slaughter using a portable pH/temperature meter (Jenco Electronic Ltd, Model 6009) fitted with a polypropylene spear-type gel electrode (Ionode IJ42S, Brisbane, QLD) and a temperature probe. Drip loss from the *Longissimus* muscle was measured using the filter paper method (Honikel, 1987). Surface lightness (L^*) of the *Longissimus* muscle was measured using a Minolta Chromameter CR-400, using D_{65} lighting, a 2^o standard observer and a measuring aperture of 8mm, standardised to a white tile. Loin samples were also used to measure cook loss and shear force. Shear force of the cooked sample was determined using a Warner Bratzler shear blade fitted to an Instron Universal Testing Machine.

One hundred and fifty boneless *Longissimus thoracis* steaks were used for the sensory analysis in this study. The steaks were individually vacuum packaged and frozen approximately 24 hours post-slaughter. Ten pigs per treatment were used. Five steaks per loin (12cm portion between the 10th and the 14th rib, 2 cm thick) were used. Thirty-two boar taint free *Longissimus* steaks (20mm thickness) were also collected for use as "warm-up steaks" during the cooking of pork samples. The steaks were thawed and cooked according to a standard protocol. The pork steaks were cooked using a Silex flat-plate grill for approximately five minutes to a standardised degree of doneness (medium/well-done, 190°C until an internal temperature of 75°C was reached). The cooking method ensured that steaks were not contaminated with flavour components from other steaks being tested concurrently. The cooked steaks were rested for 2 min, cut into half (width-ways) and immediately presented to consumers for evaluation. Consumers assessed the steaks for odour, tenderness, juiciness, flavour and overall acceptance using a line scale where 1 = dislike extremely to 100 = like extremely. The consumer taste panel were also asked to grade the pork into one of 5 quality grades where, 1 = unsatisfactory, 2 = below average, 3 = average, 4 = above average, 5 = premium

Results and Discussion

The results indicate that there was no significant difference ($P>0.005$) in carcass weight and carcass dressing % between the dietary treatments. There were no significant differences ($P>0.05$) in P2 backfat depth between the dietary treatments. The results indicate that pigs fed the 15% reduced protein:energy diet had significantly higher ($P<0.05$) IM fat levels (1.8%) compared to pigs fed the control (1.4%) and the Vit A restricted diets (1.5%). These results are in contrast to that reported by D'Souza *et al*. (2003) where pigs fed either the 15% reduced protein to energy ratio diet, or the vitamin A restricted diet had significantly higher IM fat levels compared to pigs fed the control diets.

It has been hypothesised that the effect of Vit A on IM fat deposition is mediated by retinoic acid, a derivative of Vit A, which regulates the adipogenic differentiation of fibroblasts, inhibiting the terminal differentiation of intramuscular adipose tissue in cattle (Kuri-Harcuch, 1982). It has also been proposed that retinoic acid regulates growth hormone gene expression (Bedo *et al*., 1989), which in turn decreases fat deposition and marbling in steers (Dalke *et al*., 1992). The results from the previous study by D'Souza *et al.* (2003) indicated that feeding pigs a Vit A restricted diet during the grower and finisher phase significantly lowered liver Vit A levels compared to the pigs fed a control diet. Hence it is possible that the Vit A levels in the Vit A restricted pigs in this experiment were not depleted sufficiently to result in increased IM fat levels. A similar variable response to Vit A restricted diet has been observed in cattle. Vitamin A depletion was found to be dependant Vit A levels at birth of the new born calf (in turn dependant on its the mother's Vit A levels) and hence time taken to deplete the Vit A levels sufficiently to increase IM fat levels was significantly different (D. Pethick, Personal communication).

Pork from the 15% reduced protein:energy treatment had significantly lower ($P=0.010$) ultimate muscle pH, was paler ($P=0.004$) (higher L^*) and had a higher ($P=0.006$) b^* value (yellowness-blueness) compared to pork from the control treatment group. There was no significant difference ($P>0.05$) in surface exudate, cook loss % and shear force of pork between the dietary treatments. The sensory pork quality results indicate that there was no significant difference ($P>0.05$) in aroma and flavour of pork from the different dietary treatments, although pork from pigs fed the 15% reduced protein:energy diet tended to have better flavour ($P=0.098$) scores compared to pigs fed the Vit A restricted diet. Pork from pigs fed the 15% reduced protein:energy diet was considered to have the best ($P=0.001$) juiciness, tenderness, and overall acceptability, followed by pork from the control treatment, while pork from the Vit A restricted diet was least preferred. Although significantly higher ($P=0.004$), consumers rated the pork from pigs fed the 15% reduced protein:energy diet with the same quality grade (ie Grade 3) compared to pork from control pigs.

Threshold levels of IM fat required for optimal eating quality have been reported to be about 2.5 % (Bejerholm and Barton Gade, 1986). While the IM fat levels in the 15% reduced protein to energy diet group in this experiment were below the threshold levels required for optimal eating quality, the pork was considered to have better juiciness, tenderness and overall acceptability compared to pigs fed the control and the Vit A restricted diet. However, the quality grade assigned by the consumer panel in this experiment suggests that consumers still class the eating quality of pork from the 15% reduced protein to energy diet treatment as having average eating quality and being similar to pork from the control diet treatment. This suggests that the IM fat levels needs to be near or above the threshold of 2.5% to significantly improve the eating quality of pork to a higher quality grade (ie quality grade 4 or 5).

Conclusions

The results from this experiment indicate that feeding pigs a 15% reduced protein to energy ratio diet significantly increased IM fat levels compared to pigs fed a control diet and pigs fed a Vit A restricted diet during the grower and finisher growth phase. Pork from pigs fed the 15% reduced protein to energy ratio diet were found to have better tenderness, juiciness and overall acceptability scores compared to pork from the control and Vit A restricted diet treatments.

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Table 1. The effect of grower and finisher phase dietary treatments on carcass quality and objective and sensory (consumer taste panel) pork quality of the *Longissimus thoracis* muscle of group housed female pigs.

	Dietary Treatments				
	Control	**- 15% P:E**	**-Vit A**	**L.s.d.**	**P-values**
No. of Pigs	21	21	21	-	-
Liveweight (kg)	107.0	103.4	106.1	6.59	0.520
Carcass weight (kg)	72.3	70.7	71.4	4.78	0.798
P2 (mm)	12.7	12.3	13.4	1.46	0.304
IM FAT %	1.4	1.8	1.5	0.255	0.007
Muscle pH (24h)	5.63	5.44	5.54	0.121	0.010
Muscle colour					
L*	48.9	52.9	51.0	2.31	0.004
a*	6.09	6.79	5.98	0.853	0.127
b*	4.17	5.27	4.48	0.678	0.006
Surface exudate (mg)	55.6	49.8	40.2	16.4	0.172
Cook loss (%)	32.5	32.8	30.8	2.27	0.163
Shear force (kg)	5.3	4.7	4.7	0.825	0.185
Consumer taste panel:					
Aroma[A]	68	66	65	6.74	0.635
Flavour[A]	68	72	65	6.83	0.098
Juiciness[A]	57	67	49	9.09	0.001
Tenderness[A]	55	69	52	8.96	0.001
Overall acceptability[A]	67	74	58	7.85	0.001
Quality grade[B]	3.4	3.7	3.1	0.358	0.004

[A]Line score; 1 = dislike extremely; 100 = like extremely
[B]Quality grade score; 1 = unsatisfactory, 2 = below average, 3 = average, 4 = above average, 5 = premium