Effect of dietary NDF content on growth rate and efficiency of finisher pigs

06N083

A report on an internal research project conducted by QAF Meat Industries Pty Ltd

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01 August 2007

Summary

Non-starch polysaccharides (NSP), which are comprised of soluble and insoluble fractions, are generally considered to be detrimental to growth performance. Soluble NSP is associated with increased viscosity of digesta, high water holding capacity and reduced transit rate. The effects of soluble NSP include reduced rate of diffusion of substrates and enzymes (Ikegami et al., 1990), reduced feed intake in pigs (Thacker et al., 2002) and increased microbial fermentation in the small intestine as result of slower rate of passage (Choct et al., 1996). Insoluble NSP's make up the bulk of crude fibre, and while it is believed they have little affect on nutrient absorption they may have other characteristics that affect the nutrition of pigs. Neutral detergent Fibre (NDF) encompasses the hemicellulose, cellulose and lignin components of fibre. The wheat by-product, millmix, is high in NDF and rich in insoluble NSP. Noblet and Le Goff (2001), indicate that increasing the level of NDF reduces the digestibility of diets, and that NDF fermentation provides little or no supply of energy to the young animal. However, the negative effect in older, or heavier pigs, is reduced and dietary fibre can provide a positive energy supply to mature animals. Part of this experiment focuses on using NDF, from wheat, as a strategic nutrient to improve intake and efficiency of growth pigs. The non-cellulose and non-lignin component of dietary fibre (hemicellulose), sourced primarily from wheat by-products, may be critical for the optimum dynamics and function of the gut. It is thought that there is likely to be an optimum range of dietary NDF, from wheat by-product, where feed intake is maximised and efficiency is improved.

The hypothesis of this experiment was that NDF, from the wheat by-product millmix, and supplemental fat have nutritional properties other than their chemical composition and digestible energy that enhance growth performance and efficiency in progeny.

The results of the experiment showed that increasing the level of NDF in the diet improve feed conversion throughout the experiment producer a similar carcass weight animal with lower body fat as represented by backfat depth at the P2 site. There was also an initial (during the first 14 days) increase in growth rate with increasing level of NDF in the diet which followed through as a numerical increase in liveweight at the end of the experiment.

The implications of this experiment show that the NDF level of the diet should be optimised to allow optimum growth performance and lean protein deposition. The optimised level will be dependant on the mix of raw materials available and the relative costs but will improve the cost effectiveness of using more fibrous by product efficiently.

Animal Welfare considerations

No adverse welfare notations were recorded during this experiment

Introduction

Non-starch polysaccharides (NSP), which are comprised of soluble and insoluble fractions, are generally considered to be detrimental to growth performance. Soluble NSP is associated with increased viscosity of digesta, high water holding capacity and reduced transit rate. The effects of soluble NSP include reduced rate of diffusion of substrates and enzymes (Ikegami et al., 1990), reduced feed intake in pigs (Thacker et al., 2002) and increased microbial fermentation in the small intestine as result of slower rate of passage (Choct et al., 1996). Insoluble NSP's make up the bulk of crude fibre, and while it is believed they have little affect on nutrient absorption they may have other characteristics that affect the nutrition of pigs. NDF encompasses the hemicellulose, cellulose and lignin components of fibre. The wheat by-product, millmix, is high in NDF and rich in insoluble NSP. Noblet and Le Goff (2001), indicate that increasing the level of NDF reduces the digestibility of diets, and that NDF fermentation provides little or no supply of energy to the young animal. However, the negative effect in older, or heavier pigs, is reduced and dietary fibre can provide a positive energy supply to mature animals.

Part of this experiment focuses on using NDF, from wheat, as a strategic nutrient to improve intake and efficiency of growth pigs. The non-cellulose and non-lignin component of dietary fibre (hemicellulose), sourced primarily from wheat by-products, may be critical for the optimum dynamics and function of the gut. It is thought that there is likely to be an optimum range of dietary NDF, from wheat by-product, where feed intake is maximised and efficiency is improved. The inclusion of wheat bran (insoluble NSP) can significantly increase the digesta transit rate in pigs through mechanical effects, rather than through effects on microbial fermentation and WHC. In fact, linear increases in digesta flow rate and feed intake have been measured when crude fibre was raised from 0 to 5.5% through the addition of wheat bran in 9.5 kg pigs (Schnabel et al., 1983). It has been suggested that the influence of insoluble NSP on digesta flow rate and voluntary feed intake was more a factor of particle size and fibre type, rather than the amount of insoluble NSP in the diet. Cereal fibre, especially arabinoxylan, has a markedly higher influence on digesta flow rate than insoluble NSP from vegetable fibre. It is postulated that the poor degradation of wheat and oat fibre in the colon allows the insoluble NSP to maintain its water holding capacity and mechanical bulking effects. Particle size is also an important physical factor required to enhance the bulking effects in the colon. The fine grinding of wheat bran was found to negate the possible attributes of wheat fibre (insoluble NSP) on digesta flow rates in pigs and in humans (Kirwan et al., 1974) . The increase in insoluble NSP from wheat bran and millrun could be a viable method of improving voluntary feed intake and growth of young and old pigs, especially when potential growth restricting NSP and phytic acid are deactivated by an added xylanase and phytase.

One initial study, using millrun (50%) based-diets, produced similar daily weight gains to wheat-based diets in young pigs, even though they contained 1 MJ DE less per kg diet. On average, the millrun-based diet increased voluntary feed intake by 18.8%, which supports the above observations (Cadogan, 2004). Another study in weaner pigs showed the inclusion of 25% millmix, which increased the NDF from 7 to 15%, significantly increased feed intake, daily gain and numerically improved FCR (Philpotts, unpublished). A small pilot study in finishers also suggested that increasing dietary NDF from millmix can increase growth rate (10%) and FCR (5%). The diets in the three initial studies contained xylanase and phytase. This observation again supports the benefits of coarse, insoluble NSP from wheat, once the potential anti-nutritional effects of soluble NSP and phytic acid are reduced.

Project Implications

Improved intake and or efficiency from an optimum level of dietary NDF decreases the cost of production and improve over all profitability

Project Hypotheses

NDF, from the wheat by-product millmix, and supplemental fat have nutritional properties other than their chemical composition and digestible energy that enhance growth performance and efficiency in progeny.

Materials and Methods

This experiment was designed as a 2 x 6 factorial experiment with sex and dietary level of neutral detergent fibre (NDF) as factors. The two sexes were intact male and female pigs. There were 6 formulated levels of dietary NDF in the diet including 13%, 15%, 17%, 19%, 21% and 23% of the diet. All other nutrients were formulated to be equal across all treatments. The diet was formulated to contain 13.5 MJ of digestible energy and 0.52g of available lysine per megajoule of digestible energy with the addition of a zylanase and phytase enzyme. The specifications and formulated inclusion of raw materials is shown in the Appendix. Each week for eleven weeks nine male and nine female pigs were stratified by weight and allocated from the group of 108 pigs to each of the 6 dietary treatments. The pigs were on average 65 kilograms liveweight and 16 weeks of age at the start of the experiment.

There were 1188 pigs in total. The pigs were immediately offered there respective treatment diets on an ad-libitum basis. The pigs were weighed in pen groups at the beginning of the experiment and again at 14, 28 and 35 days of the experimental period. Feed was reconciled at these times for the calculation of feed efficiency. All deaths and removals were recorded and taken into account when calculating feed intake and feed efficiency. At day 35 of the experiment the pigs were sent for slaughter at the abattoir where Hot standard carcass weight and fat depth at the P2 site were measured with calculation of dressing percentage from live weight and carcass weight.

From the final replicate (week) of pigs a random selection of 5 pigs per pen will be selected after the final 35 day weight and fasted for 12 hours and a blood sample taken for insulin and glucose levels. After slaughter tissue samples from these selected pigs will also be kept for latter analysis if required.

Results

The growth performance of the pigs over the first two weeks of the experiment is shown in Table 1. Males had a slightly higher starting weight than females. There was no significant difference in 14 day weight with NDF level of the diet but a significant linear improvement ($p=0.002$) in growth rate with increasing level of NDF in the diet. There was a significant improvement in feed conversion with increasing levels of NDF in the diet ($p=0.001$). This improvement tended to be linear with increasing level of NDF. There was no significant effect of NDF level on average daily feed intake. Female pigs grew faster ($p=0.009$) with a higher feed intake ($p=0.000$) and were less efficient ($p=0.008$) than male pigs during this period.

The growth performance over the second two weeks of the experiment is shown in Table 2. There was no effect of NDF level on any performance parameter measured during this period. Male pigs grew faster with a lower feed intake and better feed conversion than female pigs during this period.

Table 3 shows the performance of the pigs during the final week of the experiment and given this short time frame the variation within the measured parameters is high. There was no effect of NDF level on any parameter measured during this period. Male pigs grew faster with a lower feed intake and better feed conversion than female pigs during this period.

The performance of the pigs over the complete experimental period of 35 days is shown in Table 4. There was a tendency for a linear improvement in feed efficiency with increasing levels of NDF in the diet. There was no significant difference in growth rate or feed intake over the total experiment. Male pigs grew faster with a lower feed intake and better feed conversion than female pigs over the total experimental period.

The measurements recorded on the carcasses from the pigs on the experiment are shown in Table5. There was no effect of NDF level in the diet or sex of the pig on carcass weight. There was a significant linear decrease in the measured backfat depth at the P2 site with increasing levels of NDF in the diet. There was a significant linear decrease in dressing percentage associated with increase NDF levels of the diet. As expected, male pigs had a lower backfat P2 depth and dressing percentage than gilts.

Blood and tissue analysis is not available at this time but has been stored for future analysis of required.

Table 1. The performance of finisher pigs on diets with graded levels of Neutral Detergent Fibre (NDF) in the diet. (Day 0-14 of the experiment)

	NDF Level of the Diet (%)							
	13	15	17	19	21	23	Average	SEM
Females								
Start weight (Kg)	65.0	65.1	65.0	65.0	65.1	65.1	65.0	4.5
14 day weight (Kg)	78.0	78.5	79.1	78.8	78.7	78.6	78.6	4.8
Rate of gain (kg/d)	0.937	0.960	1.016	0.989	0.981	0.969	0.975	0.120
Feed Conversion	2.575	2.492	2.417	2.352	2.377	2.401	2.436	0.306
Daily feed intake (kg/d)	2.392	2.388	2.437	2.315	2.320	2.318	2.362	0.211
Males								
Start weight (Kg)	65.7	65.6	65.6	65.6	65.7	65.6	65.6	4.5
14 day weight (Kg)	78.1	78.2	78.3	78.4	79.1	79.7	78.6	4.8
Rate of gain (kg/d)	0.895	0.902	0.914	0.919	0.964	1.014	0.934	0.132
Feed Conversion	2.502	2.415	2.328	2.324	2.272	2.204	2.341	0.324
Daily feed intake (kg/d)	2.231	2.176	2.120	2.131	2.147	2.217	2.170	0.199

	NDF	SEX	NDF X SEX	Linear	R^2	Quadratic	R^2
Start weight (Kg)	1.000	0.214	1.000				
14 day weight (Kg)	0.882	0.943	0.937	0.377	0.006	0.661	0.007
Rate of gain (kg/d)	0.059	0.009	0.109	0.002	0.072	0.009	0.073
Feed Conversion	0.001	0.008	0.825	0.000	0.134	0.000	0.144
Daily feed intake (kg/d)	0.295	0.000	0.202	0.104	0.021	0.217	0.024

Table 2. The performance of finisher pigs on diets with graded levels of Neutral Detergent Fibre (NDF) in the diet. (Day 14-28 of the experiment)

	NDF Level of the Diet (%)							
	13	15	17	19	21	23	Average	SEM
Females								
14 day weight (Kg)	78.0	78.5	79.1	78.8	78.7	78.6	78.6	4.8
28 day weight (Kg)	91.4	91.1	92.9	91.6	92.0	92.4	91.9	1.7
Rate of gain (kg/d)	0.957	0.913	0.989	0.922	0.954	0.992	0.954	0.057
Feed Conversion	2.874	2.961	2.888	2.981	2.921	2.839	2.911	0.107
Daily feed intake (kg/d)	2.730	2.685	2.843	2.727	2.750	2.790	2.754	0.105
Males								
14 day weight (Kg)	78.1	78.2	78.3	78.4	79.1	79.7	78.6	4.8
28 day weight (Kg)	92.3	92.3	93.0	93.2	92.9	93.2	92.8	1.8
Rate of gain (kg/d)	1.017	1.014	1.050	1.054	0.992	0.964	1.015	0.062
Feed Conversion	2.700	2.606	2.545	2.603	2.701	2.757	2.652	0.112
Daily feed intake (kg/d)	2.730	2.628	2.655	2.725	2.670	2.590	2.666	0.110

	NDF	SEX	NDF X SEX	Linear	R^2	Quadratic	R^2
28 day weight (Kg)	0.864	0.168	0.994	0.377	0.006	0.661	0.007
Rate of gain (kg/d)	0.644	0.002	0.244	0.824	0.000	0.848	0.003
Feed Conversion	0.774	0.000	0.167	0.739	0.001	0.912	0.001
Daily feed intake (kg/d)	0.738	0.017	0.431	0.746	0.001	0.758	0.004

Table 3. The performance of finisher pigs on diets with graded levels of Neutral Detergent Fibre (NDF) in the diet. (Day 28-35 of the experiment)

	NDF Level of the Diet (%)							
	13	15	17	19	21	23	Average	SEM
Females								
35 day weight (Kg)	97.7	97.8	98.7	97.9	98.4	98.8	98.2	1.2
Rate of gain (kg/d)	0.907	0.945	0.906	0.901	0.919	0.948	0.921	0.178
Feed Conversion	3.240	3.085	3.376	3.303	3.253	3.380	3.271	0.668
Daily feed intake (kg/d)	2.884	2.868	3.001	2.825	2.914	2.979	2.910	0.267
Males								
35 day weight (Kg)	99.2	99.5	99.9	100.2	100.7	99.8	99.9	1.4
Rate of gain (kg/d)	0.993	1.028	0.991	1.019	1.094	0.947	1.012	0.173
Feed Conversion	2.786	2.844	2.826	2.818	2.649	2.922	2.808	0.340
Daily feed intake (kg/d)	2.749	2.894	2.764	2.843	2.783	2.695	2.788	0.255

	NDF	SEX	NDF X SEX	Linear	R^2	Quadratic	R^2
35 day weight	0.947	0.025	0.994	0.495	0.004	0.698	0.006
Rate of gain	0.737	0.001	0.659	0.742	0.001	0.946	0.001
Feed Conversion	0.765	0.000	0.908	0.840	0.000	0.578	0.009
Daily feed intake	0.942	0.004	0.181	0.900	0.000	0.863	0.002

Table 4. The performance of finisher pigs on diets with graded levels of Neutral Detergent Fibre (NDF) in the diet. (Day 0-35 of the experiment)

	NDF Level of the Diet (%)							
	13	15	17	19	21	23	Average	SEM
Females								
Rate of gain (kg/d)	0.939	0.938	0.967	0.945	0.957	0.968	0.952	0.058
Feed Conversion	2.808	2.780	2.799	2.743	2.738	2.732	2.767	0.126
Daily feed intake (kg/d)	2.624	2.603	2.690	2.582	2.611	2.638	2.624	0.104
Males								
Rate of gain (kg/d)	0.963	0.972	0.983	0.993	1.004	0.981	0.983	0.064
Feed Conversion	2.636	2.576	2.509	2.531	2.480	2.526	2.543	0.105
Daily feed intake (kg/d)	2.534	2.499	2.461	2.510	2.477	2.460	2.490	0.106

	NDF	SEX	NDF X SEX	Linear	R^2	Quadratic	R^2
Rate of gain (kg/d)	0.668	0.013	0.929	0.220	0.012	0.387	0.015
Feed Conversion	0.086	0.000	0.729	0.026	0.039	0.073	0.041
Daily feed intake (kg/d)	0.920	0.000	0.397	0.326	0.008	0.589	0.008

Table 5. The carcass measurements on finisher pigs fed diets with graded levels of Neutral Detergent Fibre (NDF) in the diet.

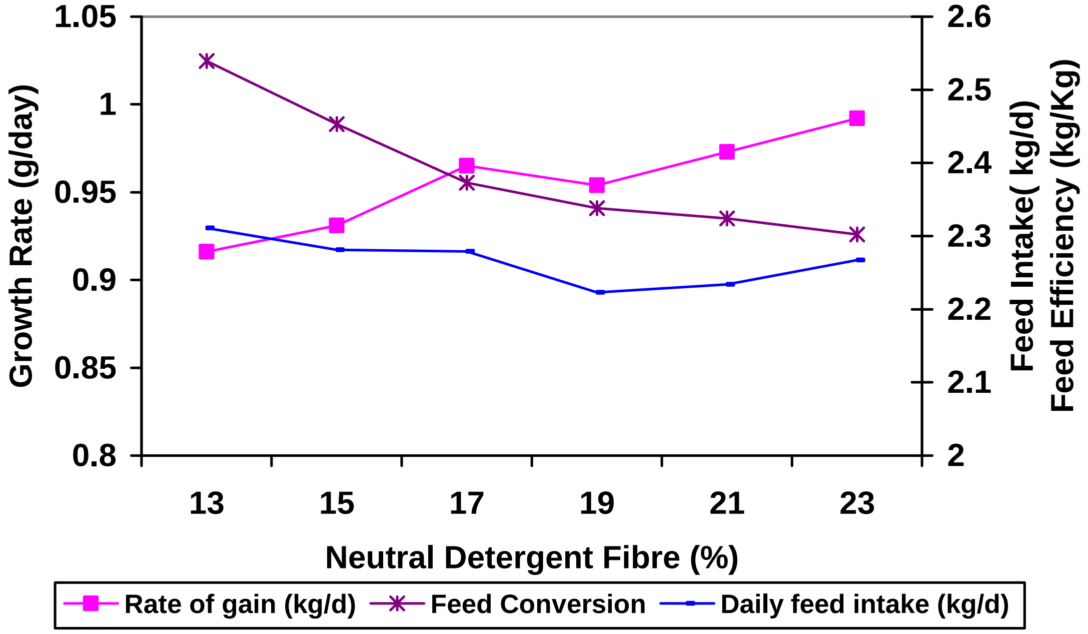
	NDF Level of the Diet (%)							
	13	15	17	19	21	23	Average	SEM
Females								
Carcass weight (kg)	76.91	76.42	77.05	76.28	76.05	76.23	76.50	0.39
Carcass P2 fat depth (mm)	9.65	9.62	9.57	9.35	9.27	9.07	9.43	0.10
Dressing percentage (%)	78.77	78.22	78.10	77.96	77.61	77.56	78.05	0.13
Males								
Carcass weight (kg)	76.29	76.33	76.53	76.12	76.67	75.36	76.21	0.47
Carcass P2 fat depth (mm)	9.33	9.28	9.09	8.90	9.16	8.42	9.03	0.10
Dressing percentage (%)	76.89	76.73	76.38	75.90	76.19	75.55	76.28	0.14
	NDF	SEX	NDF X SEX	Linear	R^2	Quadratic	R^2	
Carcass weight	0.966	0.669	0.990	0.455	0.004	0.695	0.006	
Carcass P2 fat depth	0.036	0.007	0.926	0.001	0.077	0.004	0.084	
Dressing percentage	0.001	0.000	0.860	0.000	0.097	0.002	0.097	

Discussion

The Neutral Detergent Fibre (NDF) component of a diet encompasses the hemicellulose, cellulose and lignin components of fibre. It is generally consider to be the most complete of the descriptions of fibre. It takes into account the soluble and insoluble parts of the fibre fraction of the diet. Both these portions are important for there physical properties in the diet as well as their chemical properties. Studies by Bikker and others show increasing the level of NDF in the diet generally decreases digestibility of amino acids but increases the availability of those absorbed amino acids. Associated with this is an increase rate of passage for digesta and thus an increase in voluntary feed intake. The increase in voluntary feed intake often seen with increasing fibre content of the diet is an adaptation to maintain a constant energy intake of the pig (Henman 2005) but then physical and social constraints then impinge upon this ability to maintain a constant energy intake and the result being a reduction in daily energy intake. The physical constraints involve the physical limitation of the gut which is relative to the size of the pig and also the physical properties of the diet itself. A finely ground diet will have a much greater surface area available for digestion and also have a faster rate of passage through the gut than a coarsely ground diet (Hancock 19995). If the faster rate of passage and greater utilisation of nutrients can increase the daily utilisation of nutrients a faster growth response and better feed conversion may result. Cadogan (2004) showed an 18.8% increase in voluntary feed intake with the use of a 50% wheat pollard/bran significantly improved weight gain in weaner pigs with similar results from unpublished results by Philpotts. Importantly these experiments in weaners used multi enzyme dietary additives to reduce any anti nutritive effects often seen with non starch polysaccharides and phytic acid.

The aim of this experiment was to identify where in a range of NDF levels that performance would be maximised from a growth performance perspective. The 13%-23% range of NDF levels was carefully chosen to represent levels that would be commercially viable for a finisher pig. The results of the pigs during the first two weeks of the experiment are shown in Table 1 and graphically in Figure 1. There was no change in feed intake over this period as expected but a significant linear increase in growth rate and an improvement in feed conversion efficiency. This difference in feed efficiency and growth rate did not progress into the second and third period of the experiment as shown in Figure 2. The voluntary feed intake did not change with the increasing level of NDF as expected. This difference in response between the two periods is difficult to explain but maybe related to gut fill effects with the 14 day weighing despite every effort to minimise this effect. It is possible that the pig is adapting to the new diet although there was little response to feed intake during any period which tends to suggest that there was no adaptation. Over the entire period the feed conversion efficiency showed a significant linear improvement with increasing levels of NDF in the diet but the rate of gain and feed intake showed no difference which was reflected in the carcass weight results. The linear reduction in carcass backfat depth supports the improvement seen in feed efficiency suggesting that there is probably an improvement in lean meat yield from the carcass given the similar carcass weights between the pigs fed the different levels of NDF in the diet. The improvement in lean meat yield from the carcass must be a result of the improvement in digestion and utilisation of nutrients from the diet as there was no significant difference in feed disappearance and thus amino acid or energy intake. This is in contrast to the work done by Bikker where NDF reduce nutrient digestibility but they did see an increase in rate of passage and total nutrient intake not seen in this experiment. Generally as a nutrient becomes more limiting the digestibility of that nutrient increases which is a natural adaptation in response to nutrient gradients and a passive mechanism. If this mechanism was more of an active transport system and the presence of increased levels of NDF triggered a natural increase in absorption and utilisation of nutrients independent of the passive mechanism then this could be exploited if the voluntary feed intake of the animal could be managed. The result may also suggest that our measurement of net energy on millmix is significantly wrong which is possible given the difficulty of determining net energy on a variable product such as millmix. Further work in elucidating this mechanism should be carried out considering fixed feed intakes and the relevant levels of all fibre components of the diet as this result maybe dependant on the raw materials involved rather than the fibre components.

The linear decrease in dressing percentage of the pigs fed with increasing levels of NDF in the diet suggests that the intestinal tract of the pig has increased in weight. This has been seen in most experiments with increasing levels of Fibre in the diet (references required) and this experiment was no exception and does indicate the physical parameters of the diet can significantly impact on the intestinal tract and should be considered when looking at any diet. While the differences were subtle the differences are important from a processing point of view as it may change some of the processing requirements associated with full intestines and clearance rates as well as the economics of the abattoir.



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igure 1: Performance of pigs during the first 14 days of pigs fed graded levels of NDF in the diet

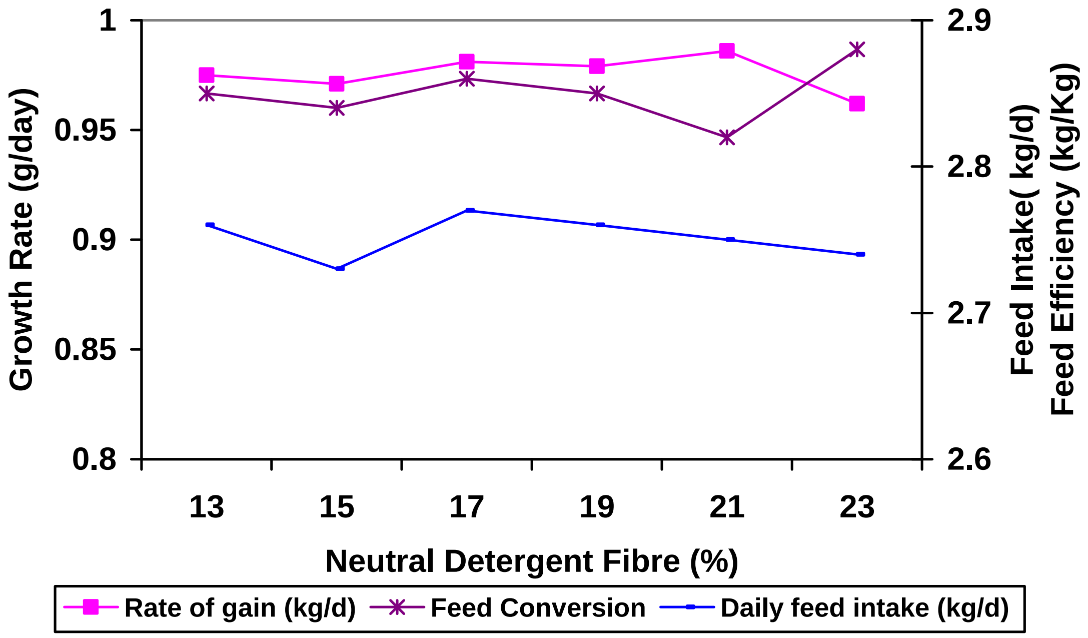

Figure 2: Performance of pigs during the last 21 days of pigs fed graded levels of NDF in the diet

Implications

In general most finisher type diets are not formulated on Neutral Detergent Fibre levels of the diet but rather on crude fibre levels. The response of pigs to crude fibre is generally associated with decreasing performance with increasing levels of crude fibre due to the decrease in daily energy utilisation. Utilisation of the Neutral Detergent Fibre level of the feed in isolation to the energy density of the diet has shown from this experiment that improvements in lean meat yield and feed conversion efficiency can be achieved with the increasing levels of NDF. When these diets were original formulated there was a reduction in diet cost of $12.50 per tonne from the diet containing 13%NDF to the 23% NDF diet. These formulations were based on the highest and lowest NDF levels whereas in commercial operations individual diets would be considered separately and many factors associated with availability of the raw materials would influence the result. Formulations examples over the last 5 years show that the lowest cost diet is at the 19% NDF level diet using millmix as the major source of NDF. These assumptions should be considered with parametric nutrition formulations for each set of ingredient circumstances. Table 6 shows the possible advantage in cost of production that can be achieved from increasing the NDF level of the diet. If we assume that under commercial practice the most cost effective diet is likely to contain an NDF level of 19% we can achieve a saving in cost of production of 3 cents per kilogram of liveweight.

Table 6. Cost Analysis of increasing NDF level for Finisher pigs.

NDF Level (%)	13	15	17	19	21	23
Total Feed consumed (Kg)	89.7	88.8	89.6	88.6	88.5	88.7
Cost of feed ($)	18.85	18.42	18.37	17.94	17.71	17.52
Liveweight Gain (Kg)	32.71	32.67	33.74	32.90	33.33	33.75
cost/kg ($/kg)	0.576	0.564	0.545	0.545	0.531	0.519
Difference to 13%NDF (cents/Kg)		-1.24	-3.17	-3.10	-4.50	-5.72

In a long term average raw material pricing matrix in Australia increasing levels of NDF in the diet to 19% will reduce the cost of the diet and improve the cost per megajoule per unit of gain. These circumstances need to be reviewed based on the cost of available raw materials. In this experiment Millmix was used as the NDF source with an expected value of 75% the cost of wheat. Recently the availability and cost of this by-product suggests that it would be prudent to examine other ingredients that contain high levels of NDF and relatively low Acid Detergent Fibre levels. Further work arising from this experiment is the investigation into the increasing lean deposition occurring from the higher NDF diets. Is it driven by an increase in nutrient absorption and utilisation or the nutrient description for millmix is incomplete from a net energy point of view.

APPENDICES

- **Protocol**

- **Experimental Diets**

PROTOCOL

APPROVED (12.12.06)

PROTOCOL 06N083 **A. Philpotts** April 2, 2009

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Internal

Introduction

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Part of this experiment focuses on using NDF, from wheat, as a strategic nutrient to improve intake and efficiency of growth pigs. The non-cellulose and non-lignin component of dietary fibre (hemicellulose), sourced primarily from wheat by-products, may be critical for the optimum dynamics and function of the gut. It is thought that there is likely to be an optimum range of dietary NDF, from wheat by-product, where feed intake is maximised and efficiency is improved. The inclusion of wheat bran (insoluble NSP) can significantly increase the digesta transit rate in pigs through mechanical effects, rather than through effects on microbial fermentation and WHC. In fact, linear increases in digesta flow rate and feed intake have been measured when crude fibre was raised from 0 to 5.5% through the addition of wheat bran in 9.5 kg pigs (Schnabel et al., 1983). It has been suggested that the influence of insoluble NSP on digesta flow rate and voluntary feed intake was more a factor of particle size and fibre type, rather than the amount of insoluble

NSP in the diet. Cereal fibre, especially arabinoxylan, has a markedly higher influence on digesta flow rate than insoluble NSP from vegetable fibre. It is postulated that the poor degradation of wheat and oat fibre in the colon allows the insoluble NSP to maintain its water holding capacity and mechanical bulking effects. Particle size is also an important physical factor required to enhance the bulking effects in the colon. The fine grinding of wheat bran was found to negate the possible attributes of wheat fibre (insoluble NSP) on digesta flow rates in pigs and in humans (Kirwan et al., 1974) . The increase in insoluble NSP from wheat bran and millrun could be a viable method of improving voluntary feed intake and growth of young and old pigs, especially when potential growth restricting NSP and phytic acid are deactivated by an added xylanase and phytase.

One initial study, using millrun (50%) based-diets, produced similar daily weight gains to wheat-based diets in young pigs, even though they contained 1 MJ DE less per kg diet. On average, the millrun-based diet increased voluntary feed intake by 18.8%, which supports the above observations (Cadogan, 2004). Another study in weaner pigs showed the inclusion of 25% millmix, which increased the NDF from 7 to 15%, significantly increased feed intake, daily gain and numerically improved FCR (Philpotts, unpublished). A small pilot study in finishers also suggested that increasing dietary NDF from millmix can increase growth rate (10%) and FCR (5%). The diets in the three initial studies contained xylanase and phytase. This observation again supports the benefits of coarse, insoluble NSP from wheat, once the potential anti-nutritional effects of soluble NSP and phytic acid are reduced.

Project Implications

Improved intake and or efficiency from an optimum level of dietary NDF decreases the cost of production and improve over all profitability

Project Hypotheses

NDF, from the wheat by-product millmix, and supplemental fat have nutritional properties other than their chemical composition and digestible energy that enhance growth performance and efficiency in progeny.

Materials and Methods

Design:	2 x 6 Sex (male/female) and NDF (13%, 15%, 17%, 19%, 21%, 23% dietary NDF) as factors.
Site:	Commercial Finisher
Animals Required:	1188 pigs (99 male and 99 female per treatment) at average 60kg (±2.5 kg) live weight 2 pens of 9 pigs (108) per treatment per week for 11 weeks
Age:	16 weeks
Treatments:	Assigned as per level of added dietary NDF A. Finisher 13% NDF B. Finisher 15% NDF C. Finisher 17% NDF D. Finisher 19% NDF E. Finisher 21% NDF F. Finisher 23% NDF Formulated to 13.5 DE/kg, 0.52 g of available lysine/MJ
Start Date:	Week 7
Duration:	5 weeks (35 days) feeding period 11 weeks of replication
Feed Required:	20 tonnes per treatment All feed to be formulated at 13.5 MJDE and 0.52 g of available lysine/MJ All feeds to contain a coloured microgrit marker
Laboratory Analyses: (To include all analyses required by Mill Laboratory)	
Medication:	As per script 1kg/tonne Elancoban Water medications as per QI 128

Measurements:	o Start weights and weights at 14 day intervals (0,14,28,35 days) o Average daily intake o Feed conversion o Deaths, removals and reason for death or removal o Final pen live weight o Carcass weight o HC grading P2
Data Safety Sheets/ Information: (must be attached for new products/additives)	N/A
Ethical Considerations: (is Ethics Committee approval required?)	
QA Documentation	
Production Considerations	
Processing Considerations:	o Carcass weight o HC grading P2
Co-Ordinator (as FTE if this is a CRC Project)	0.15 manager 0.2 Researcher
Technical Assistant(s) (as FTE if this is a CRC Project)	0.5 for duration of experiment
Monitor	

Please complete the relevant costings table of the two tables shown below.

Project Costings (for internal or other contract trials):

Items	**$ (AUD)**	
Labour ($27.50 / hr)		
Diet Costs		
Animal charge		
Data Collection and Analysis		
Technical Services and Management		
Chemical Analysis		
Contract Fee Chargeable		
Total	**$ 0**	***GST exclusive***

OR

Project Costings (For CRC projects):

Items	**$ (AUD)**	**(FTE)**	
Principle investigator			
Trial Coordinator			
Research Assistant			
Diet Costs			
Animal charge			
Chemical Analysis			
Total			***GST exclusive***
CRC Cash Requested			
CRC Staff Inkind			
CRC Non Staff Inkind	**$ 0**		

Business Agreement

1. QAF Meat Industries undertakes to conduct the experiment outlined in the protocol on behalf of Name of Company for a total cost of $AUD

2. QAF Meat Industries to provide a detailed report on the results and implications of the completed experiment within six weeks of the completion date of the experimental work.

3. Name of Companyagrees to pay QAF Meat Industries $AUD on receipt of the final report.

Signed by:

.... Date ....
on behalf of Name of Company

.... Date ....
on behalf of QAF Meat Industries

PROTOCOL AMENDMENT / DEVIATION

Protocol Number: **06N083**

Protocol Title: Effect of dietary NDF content on growth rate and efficiency of finisher pigs

Amendment or Deviation (circle one): **Amendment / ~~Deviation No:~~**

Description of Amendment / Deviation:

1. Final bleeding of 5 selected pigs per pen (60 in total). Pigs will need to be fasted for 12 hours and then a blood sample will be taken from each of the selected pigs at the end of the fasted period as per current protocol. Immediately following the first blood sample, the pigs will be returned to feed with unrestricted access. 24 hours after being returned to feed another blood sample will be taken.
    - All pigs need to be returned to a common diet, with unlimited access, that contains low fat levels and high starch content, and not their treatment diets for the 24 hours prior to the final bleed. The diet to be used will be diet 9809 (05N061 A).
    - Use 11th (final) week of pigs.
2. Collection of a fat and muscle tissue sample from 5 pigs per pen (60 pigs in total) that were used to obtain blood samples.
    - The pigs need to be individually identified.
    - The samples can be taken from any site on the carcase as long as it is the same for each carcase
    - Samples may need to be collected from carcases on the kill chain to ensure all are obtained
    - The samples must be placed in ice at the point of collection and frozen as soon as practical.

Reasons for Amendment / Deviation:

1. Offering the treatment diets prior to the final bleed will not allow a proper indication of insulin sensitivity.
2. The tissue samples will be used to measure insulin and glucose content and uptake.

Impact of Amendment / Deviation:

1. Requires a change of feeding regime. A common diet to be fed to each treatment for one week of pigs for 24 hours only
2. One-off collection of 60 tissue samples

Effective Date: 18/5/07

Investigator:

Date: 18/5/07

Client:

Date: 18/5/07

EXPERIMENTAL DIETS

Experiment 2 Diets

	A	B	C	D	E	F
Wheat	67.8	61.8	55.8	49.8	43.8	37.7
Barley	17.7	15.6	13.4	11.3	9.1	7.0
Millmix	0	7.5	15	22.5	30	37.5
Canola meal	7.2	7.26	7.32	7.38	7.44	7.5
Soybean meal	3.5	3.1	2.7	2.3	1.9	1.5
Water	1.0	1.0	1.0	1.0	1.0	1.0
Tallow	0.0	1.0	2.0	3.1	4.1	5.1
Salt	0.200	0.200	0.200	0.200	0.200	0.200
Limestone	1.6	1.6	1.7	1.7	1.8	1.8
Dicalphos	0.38	0.31	0.24	0.17	0.10	0.03
Lysine HCl	0.350	0.348	0.345	0.343	0.341	0.338
DL Methionine	0.000	0.003	0.006	0.009	0.011	0.014
Threonine	0.077	0.082	0.086	0.091	0.096	0.101
Copper Proteinate	0.100	0.100	0.100	0.100	0.100	0.100
Finisher Premix	0.067	0.067	0.067	0.067	0.067	0.067
Elancoban G	0.100	0.100	0.100	0.100	0.100	0.100
Phytase	0.067	0.067	0.067	0.067	0.067	0.067
Xylanase	0.030	0.030	0.030	0.030	0.030	0.030

Experiment 2 nutrient composition.

	A	B	C	D	E	F
DE	13.5	13.5	13.5	13.5	13.5	13.5
Fat	2.0	3.2	4.3	5.4	6.6	7.7
Crude Fibre	3.7	4.1	4.5	4.9	5.3	5.8
Starch	51.8	48.4	44.9	41.5	38.0	34.5
NDF	13.3	15.3	17.4	19.4	21.4	23.4
Calcium	0.85	0.85	0.85	0.85	0.85	0.85
Avail Phosphorus	0.33	0.33	0.33	0.33	0.33	0.33
Avail Lysine/MJDE	0.53	0.53	0.53	0.53	0.53	0.53
Methionine/Lysine	0.31	0.31	0.31	0.31	0.31	0.31
Meth and Cyst/Lysine	0.71	0.71	0.70	0.70	0.69	0.68
Threonine/Lysine	0.70	0.70	0.70	0.70	0.70	0.70
Isoleucine/Lysine	0.67	0.66	0.65	0.63	0.62	0.61
Tryptophan/Lysine	0.25	0.25	0.24	0.24	0.24	0.24
Valine/Lysine	0.85	0.85	0.85	0.85	0.84	0.84

Measured NDF Levels (QAF Feeds Laboratory)

Treatment	A	B	C	D	E	F
NDF %)	13.0	15.6	16.5	19.5	20.4	23.2