EVALUATION OF JUNCEA MEAL FOR GROWING PIGS

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By

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Executive Summary

Juncea (*Brassica juncea*) has been bred as a crop for low rainfall regions in Australia, producing a seed with similar properties to that of traditional canola (*Brassica napus*). Increasing areas of the crop have been planted in the last 12 months, with approx 13,000 ha planted across southern Australia in 2010. There is currently interest in the use of juncea oil for bio-diesel production, and as such the remaining meal may be available for use in animal diets. Given the similarity of juncea meal to traditional canola meal, there is the potential to utilize this product as an alternative vegetable protein source in pig diets.

A total of 70 entire male pigs (Large White x Landrace, PrimeGro™ Genetics) were identified at 13 weeks of age (live weight 40.4 kg ± 0.41 kg) and transferred to individual grower accommodation. At 14 weeks of age, all pigs were individually weighed and randomly allocated to one of five experimental diets: Diet A: 0 % juncea meal; Diet B: 6 % juncea meal; Diet C: 12 % juncea meal; Diet D: 18 % juncea meal; Diet E: 24 % juncea meal. Diets were formulated to contain 14.0 MJ digestible energy (DE) and 0.62 g available lysine/MJ DE, with juncea meal replacing canola meal at increasing concentrations in the test diets. Pigs were offered the allocated test diets *ad libitum* for a 35 day test period with feed intake and growth performance measured during this time.

Average glucosinolate concentration in the juncea meal was measured to be 15.9 µmoles/g air dry, with the results for the individual samples ranging from 13-19 µmoles/g air dry. During the initial 21 day feeding period, there were significant linear reductions in average daily feed intake ($P=0.029$) and growth rate ($P=0.011$) with increasing juncea meal concentration. In particular, pigs offered the diet containing 24 % juncea meal consumed 12 % less feed and grew 18 % slower than pigs offered the control diets (0 % juncea meal) during this time. Results over the entire test period show a significant linear decline in feed intake with increasing juncea meal concentration ($P<0.001$). Growth performance of the pigs offered up to 18 % juncea meal was however similar to the control animals over the entire test period.

In conclusion, the results from this experiment together with the outcomes from previous pig growth studies, suggest that juncea meal may be safely included in commercial grower/finisher diets up to levels in which the total glucosinolate concentration in the complete diet does not exceed about 2.0 mmol/kg diet. Variation in total glucosinolate concentration of the meal due to differing climatic conditions during the growing season and/ or post-harvest processing may influence the maximum inclusion rate. Further discussions are required between commercial nutritionists, Smorgon Fuels and the research team to determine the economic value of the product.

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Introduction

Juncea (*Brassica juncea*) has been bred as a crop for low rainfall regions in Australia, producing a seed with similar properties to that of traditional canola (*Brassica napus*). Increasing areas of the crop have been planted in the last 12 months, with approx 13,000 ha planted across southern Australia in 2010. There is currently interest in the use of juncea oil for bio-diesel production, and as such the remaining meal may be available for use in animal diets. Given the similarity of juncea meal to traditional canola meal, there is the potential to utilize this product as an alternative vegetable protein source in pig diets. Canola meal is currently the vegetable protein source of choice for pig diets in southern Australia, with low glucosinolate canola meal able to be included in weaner diets at up to 25 %, grower or finisher diets at up to 30 % and lactating sow diets at up to 20 % without any adverse effects on performance (King *et al.* 2001). Preliminary studies in Canada have reported that feeding up to 15 % juncea meal (replacing canola meal in the diet 1:1) resulted in a 5 % improvement in growth performance and a 2.5 % improvement in feed efficiency compared to pigs offered the 15 % canola meal diet (Zijlstra *et al.* 2005). In addition, studies with broiler poultry have demonstrated that the inclusion of 20 % juncea meal in diets for growing chicks did not have any adverse effects on growth performance (Newkirk *et al.* 1997). In this study, chicks offered the juncea meal diets displayed growth rates and feed efficiencies similar to chicks offered diets containing either canola meal or soybean meal. This result was despite the juncea meal containing slightly higher concentrations of glucosinolates (an anti-nutritional factor) compared to the traditional canola meal.

Given the potential availability of juncea meal in the near future, there is a need to determine the growth response of growing pigs to increasing concentrations of juncea meal in the diet. If the growth performance of pigs offered juncea meal compares favourably with pigs offered diets containing canola meal, there will be the potential for the pig industry to utilise juncea meal as an alternative protein source if competitively priced.

Materials and Methods

Chemical analysis

In 2009, juncea crops were grown in Victoria, South Australia and New South Wales. Seed from the Victorian and South Australian harvest was crushed using an expeller press and the resultant meal recovered. Representative samples of the juncea meal were analysed for dry matter, crude protein, crude fat, neutral detergent fibre, acid detergent fibre and gross energy content by Rivalea Australia Pty Ltd (AOAC 1988). Analysis of the amino acid profile of the meal was undertaken by Evonik Degussa (Germany) as was a basic amino acid profile of the canola meal used in this study. In formulating the experimental diets, the digestible energy content of the juncea meal was assumed to be 13.0 MJ/kg and canola meal 12.4 MJ/kg. Ten representative samples of the juncea meal were analysed for total glucosinolate concentration by Industry and Investment NSW (Wagga Wagga Agricultural Institute).

Animals and treatments

A total of 70 entire male pigs (Large White x Landrace, PrimeGro™ Genetics) were identified at 13 weeks of age (live weight 40.4 kg ± 0.41 kg) and transferred to individual grower accommodation. Pigs were selected in one replicate on the 14th

September 2010. Pigs were offered a commercial grower diet (digestible energy 13.9 MJ/ kg and available lysine 0.70 g /MJ DE) for an initial seven day period while they acclimatised to the individual pens. At 14 weeks of age, all pigs were individually weighed and randomly allocated to one of five experimental diets:

Diet A: 0 % Juncea meal
Diet B: 6 % Juncea meal
Diet C: 12 % Juncea meal
Diet D: 18 % Juncea meal
Diet E: 24 % Juncea meal

Diets were formulated to contain 14.0 MJ DE and 0.62 g available lysine/MJ DE, with juncea meal replacing canola meal at increasing concentrations in the test diets. Pigs were offered the allocated test diets (Table 1) *ad libitum* for a 35 day test period. All diets were fed in a pelleted form through self feeders. Animals had *ad libitum* access to water via nipple drinkers for the entire experimental period.

Husbandry and management

Pigs were individually housed in pens with partially slatted floors in an uninsulated building with side shutters that are controlled by temperature. Individual pig weights were recorded at entry (day -7), day 0, day 21 and day 35, with individual feed intakes estimated by feed disappearance between these time periods. Individual animals wasting a large amount of feed during the test period were noted and their feed intake data removed from the data set where deemed appropriate. Feed conversion ratio was subsequently determined from rate of gain and estimated feed intake. All procedures undertaken in this investigation were approved by the Rivalea Animal Care and Ethics Committee (License SPPL 111).

Statistical analysis

Differences in growth performance between treatments were determined using an analysis of variance for a completely randomized design. The response to increasing dietary concentration of juncea meal was tested for linear and quadratic effects using the polynomial function in Genstat for Windows Version 8 (VSN International Ltd, Hertz, UK). Significant differences between dietary treatments were determined using least significant differences. Missing values were used for animals that died during the course of the experiment. The experimental unit for all analyses was the individual animal.

Table 1 - Ingredient composition and analysed nutrient profile of each of the experimental grower diets, % of diet (as fed basis)

	Concentration of Juncea meal (%)				
	0	**6**	**12**	**18**	**24**
Wheat	67.5	67.7	67.8	68.0	68.1
Canola meal	24.0	18.0	12.0	6.0	
Juncea meal		6.0	12.0	18.0	24.0
Meat meal	3.0	3.0	3.0	3.0	3.0
Water	1.0	1.0	1.0	1.0	1.0
Natuphos 5000	0.01	0.01	0.01	0.01	0.01
Porzyme 9310	0.02	0.02	0.02	0.02	0.02
Tallow	2.60	2.40	2.30	2.17	2.00
Salt	0.20	0.20	0.20	0.20	0.20
Limestone	1.17	1.17	1.17	1.17	1.17
Lysine HCL	0.30	0.29	0.28	0.27	0.27
Threonine	0.03	0.03	0.04	0.04	0.05
Copper premix	0.10	0.10	0.10	0.10	0.10
Rivalea grower premix	0.07	0.07	0.07	0.07	0.07
*Estimated nutrient composition, %**					
DE, MJ/kg	14.0	14.0	14.0	14.0	14.0
Crude protein	19.8	19.9	20.1	20.2	20.3
Crude fat	4.8	4.7	4.7	4.7	4.7
Neutral detergent fibre (NDF) %	13.9	13.5	13.2	12.8	12.5
Total Lysine	1.04	1.04	1.04	1.05	1.05
Available lysine: DE ratio g/MJ DE	0.62	0.62	0.62	0.62	0.62
*Analysed amino acid composition,%^*					
Methionine	0.34	0.33	0.33	0.33	0.33
Cystine	0.41	0.41	0.41	0.41	0.40
Lysine	1.08	1.06	1.01	1.03	1.04
Threonine	0.73	0.72	0.72	0.73	0.72
Tryptophan	0.23	0.23	0.23	0.24	0.23
Arginine	1.08	1.10	1.11	1.14	1.14
Isoleucine	0.70	0.70	0.70	0.72	0.70
Leucine	1.30	1.29	1.30	1.32	1.31
Valine	0.90	0.89	0.90	0.92	0.89
Histidine	0.47	0.46	0.46	0.47	0.47
Phenylalanine	0.81	0.81	0.81	0.82	0.81
Glycine	1.05	1.06	1.03	1.06	1.06
Serine	0.84	0.84	0.82	0.82	0.85
Alanine	0.83	0.83	0.82	0.83	0.82
Aspartic acid	1.23	1.23	1.23	1.27	1.26
Glutamic acid	4.26	4.22	4.25	4.26	4.25
*Analysed synthetic amino acid contents, %^*					
Lysine	0.24	0.22	0.20	0.22	0.22
Threonine	0.04	0.04	0.05	0.06	0.05

*Estimated from Rivalea Australia Pty Ltd composition data
^Dietary amino acid analysis undertaken by Evonik Degussa, Germany.

Outcomes

Nutrient Composition

The nutrient composition of the expeller-extracted juncea meal is displayed in Table 2 in comparison to canola meal. The nutrient profile was generally similar between the two vegetable protein meals, with the main differences being the higher fat content and lower fibre component of the juncea meal. The total amino acid profile was very similar between the two meals. Average glucosinolate concentration in the juncea meal was 15.9 µmoles/g air dry, with the results for the individual samples ranging from 13-19 µmoles/g air dry.

Growth Performance

The impact of increasing juncea meal concentration on the growth performance of grower pigs is displayed in Table 3. During the initial 21 day period, there were significant linear reductions in average daily feed intake (P=0.029) and growth rate (P=0.011) with increasing juncea meal concentration. In particular, pigs offered the diet containing 24 % juncea meal consumed less feed and grew at a slower rate during this time period compared to the control animals. During the subsequent period from 21 to 35 days, the pigs offered the diet containing 24 % juncea meal continued to consume less feed and grow slower than animals offered the other four diets. Results over the entire test period show a significant linear decline in feed intake with increasing juncea meal concentration (P<0.001), resulting in a linear reduction in growth rate during this time (P=0.009). Growth performance of the pigs offered the 18 % juncea meal diet was however similar to the control animals over the entire test period. Feed efficiency was similar across the dietary treatment groups throughout the test period.

The influence of juncea meal concentration on the number of pigs wasting feed throughout the study is displayed in Table 4. Although the number of pigs noted as wasting feed was slightly higher than normal, there was no significant impact of dietary treatment on the pattern of feed wasters (x^2=3.50, P=0.48). There were several deaths during the experimental period: 2 deaths due to general ill thrift and 8 deaths caused by *Actinobacillus pleuropnemoniae* (APP) infection. The total number of deaths tended to be greater in the treatment groups offered the control diet and the diet containing 18 % juncea meal (x^2=8.17, P=0.086).

Table 2 - Composition and amino acid profile of expeller extracted juncea meal and canola meal (% air dry basis)

Constituent*	Juncea meal (g/kg)	Canola meal (g/kg)
Moisture	10.0	10.1^
Gross energy (MJ/kg)	19.0	19.6
Crude protein	38.9	38.1^
Crude fat	6.6	4.9
Neutral detergent fibre	17.9	24.0
Acid detergent fibre	14.3	21.5
Amino acids^		
Methionine	0.67	0.76
Methionine + Cystine	1.43	1.71
Lysine	1.90	2.14
Threonine	1.51	1.61
Tryptophan	0.50	0.55
Arginine	2.49	2.39
Isoleucine	1.47	1.52
Leucine	2.57	2.69
Valine	1.83	1.94
Histidine	0.96	1.05
Phenylalanine	1.47	1.56
Glycine	1.89	NA
Serine	1.52	NA
Proline	2.03	NA
Alanine	1.60	NA
Aspartic acid	2.84	NA
Glutamic acid	6.18	NA

*Estimated from Rivalea Australia Pty Ltd laboratory analysis

^Analysis undertaken by Evonik Degussa, Germany. Canola meal values obtained using Evonik Degussa's NIRS calibration.

Table 3 - Effect of dietary Juncea meal concentration on the growth performance of grower pigs

Means within rows followed by the same letter are not significantly different at P=0.05

	Concentration of juncea meal (%)					s.e.d	Significance of response	
	0	6	12	18	24		Linear	Quadratic
Live weight								
Day 0	49.8	49.8	49.8	49.8	49.8	1.58	0.99	0.99
Day 21	72.0	72.0	68.5	69.3	69.0	2.60	0.14	0.60
Day 35	87.2	87.3	84.4	87.9	80.8	2.91	0.064	0.30
Growth rate (kg/d)								
Day 0-21	1.08[a]	1.05[a]	0.93[ab]	0.99[ab]	0.89[b]	0.073	0.011	0.88
Day 21-35	1.05[ab]	1.09[a]	1.13[a]	1.25[a]	0.84[b]	0.122	0.34	0.014
Day 0-35	1.07[a]	1.07[a]	1.03[a]	1.08[a]	0.87[b]	0.063	0.009	0.063
Feed intake (kg/d)								
Day 0-21	2.39[a]	2.37[ab]	2.31[ab]	2.28[ab]	2.11[b]	0.131	0.029	0.46
Day 21-35	2.66[a]	2.58[a]	2.62[a]	2.52[a]	2.08[b]	0.194	0.007	0.10
Day 0-35	2.55[a]	2.46[a]	2.46[a]	2.37[a]	2.09[b]	0.120	<0.001	0.14
Feed:gain (kg/kg)								
Day 0-21	2.27	2.31	2.63	2.35	2.41	0.237	0.55	0.37
Day 21-35	2.69	2.82	2.34	2.02	2.65	0.420	0.35	0.31
Day 0-35	2.38	2.35	2.40	2.20	2.45	0.134	0.99	0.38

Table 4 - Impact of increasing dietary juncea meal concentration on the total number of pigs

Noted as wasting feed, number of deaths and the number of animals requiring medical intervention during the experimental period

	Feed wasters		Medical treatments		Deaths	
Concentration of Juncea meal (%)	Day 0-21	Day 21-35	Day 0-21	Day 21-35	Day 0-21	Day 21-35
0	2	1	3	1	1 - APP	3 - APP
6	1	1	1	2	1 - APP	
12	4	1	4	1		
18	1		8	2	1 - APP	2 - Unthrifty, 1 - APP
24	2		6	2	1 - APP	

Application of Research

These data indicate that expeller-extracted juncea meal can be included in the diet for growing pigs at concentrations of up to 18 % without adversely affecting growth performance. Feed intake and growth rates are however depressed when growing pigs are offered diets containing 24 % juncea meal. The reduction in feed intake at the higher inclusion concentration of juncea meal is most likely a direct response to the higher intake of total glucosinolates. Glucosinolates are secondary plant metabolites that occur in all feedstuffs of *Brassica* origin, and which commonly have anti-nutritional impacts when consumed in high concentrations. Feed intake depressions similar to those observed in this present study have been reported when pigs are offered diets containing high concentrations of canola meal, with the magnitude of the depression in feed intake dependent on the glucosinolate concentration in the meal and the age of the pig. Mullen *et al.* (2000) observed similar growth performance when growing pigs (23-110 kg) were offered up to 20 % canola meal (average total glucosinolates 10.5 µmoles/g) on an *ad libitum* basis. In a secondary experiment however, these authors reported a tendency for decreased performance when greater than 15 % expeller extracted canola meal was included in the diet and feed intake was standardised across treatments to three times maintenance. In comparison, Corino (1991) offered growing pigs (22 to 140+ kg) a higher glucosinolate rapeseed meal (total glucosinolates 39 µmoles/g DM) at rates of 5, 10 and 15 % and observed reduced growth rates and feed intakes compared to the control animals, particularly during the initial 60 days of feeding. Plant breeding programs have enabled low glucosinolate cultivars of canola to be extensively grown across southern Australia. Growth performance studies using this low glucosinolate canola meal (4 - 5 µmoles/g air dry) have shown that up to 25 % canola meal can be included in weaner diets without adversely affecting growth performance, while this figure is 30 % in grower and finisher pigs and 20 % for lactating sows (King *et al.* 2001).

The impact of dietary glucosinolate concentration on feed intake of growing pigs across several recent investigations is displayed in Figure 1. Although the source of glucosinolates does vary between experiments (canola meal, juncea meal, rapeseed meal), it is clear that there is a reduction in feed intake when pigs consume diets with greater than 2.0 - 2.5 mmol total glucosinolates/kg diet. These glucosinolate intake levels are consistent with the most recent recommendations for breeder diets, with Schone *et al.* (2001) recommending that the total glucosinolate concentration of sow diets should not exceed 2 mmol total glucosinolates/ kg diet. Limiting the total glucosinolate concentration to 2.0 mmol /kg diet would set a safe maximum inclusion concentration of the juncea meal utilised in this investigation at 12.5%. The glucosinolate concentration of the meal will clearly need to be monitored and, where necessary, dietary inclusion levels adjusted to ensure maximum feed intake and growth performance can be obtained.

There are many factors that can influence the total glucosinolate concentration of *Brassica* meals, with a full review on this topic conducted by Tripathi and Mishra (2007). Climatic conditions during the growing season can have a substantial impact on seed concentration. In particular, periods of water stress during the vegetative or pod-filling stage have been demonstrated to increase glucosinolate concentrations (Jensen *et al.* 1996). Post harvest processing will also have an impact, with the method used for oil extraction known to influence total glucosinolate concentrations as well as the levels of other anti-nutritional factors found in vegetable protein meals. In general, expeller extracted meals contain a lower concentration of total glucosinolates than solvent extracted meals (Tripathi and Mishra 2007). If sufficient solvent-extracted juncea meal becomes available in the future for animal feeding, it is recommended that glucosinolate testing be undertaken prior to use in animal diets to assess the risk of feed aversion.

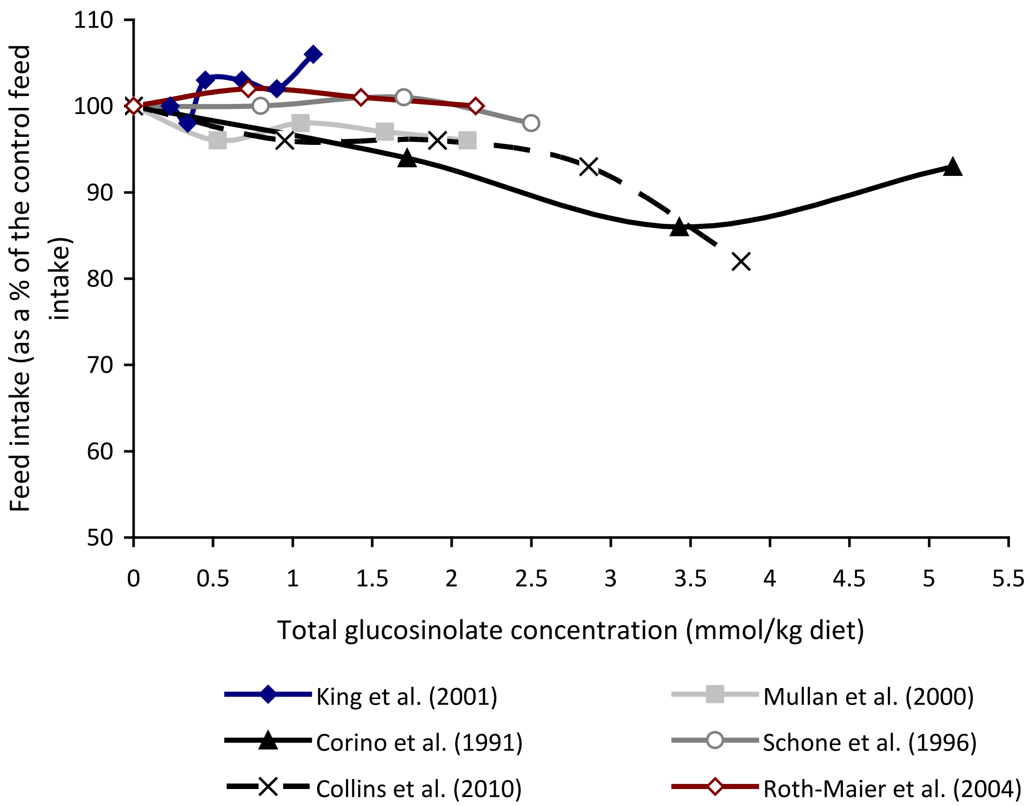

Figure 1 - Feed intake response to increasing dietary glucosinolate concentration for growing pigs. Canola meal (King *et al.* 2001; Mullan *et al.* 2000; Roth-Maier *et al.* 2004); Rapeseed meal (Corino *et al.* 1991; Schone *et al.* 1996); Juncea meal (Collins *et al.* 2010).

The use of juncea meal in pig diets will depend not only on the animal performance outcomes, but also on the availability of the meal, the magnitude of variation in quality of the product and finally the raw material cost in comparison to competing protein sources. The major competitors to the use of juncea meal in the Australian pig industry are canola meal, soybean meal, lupin kernels and meat meal. Further discussions are required between commercial nutritionists, Smorgon Fuels and the research team to determine the economic value of juncea meal.

Conclusion

The results from this study suggest that expeller-extracted juncea meal can be included in the diet for growing pigs at concentrations of up to 18 % without adversely affecting growth performance. This maximum inclusion concentration is based on the expeller-extracted meal containing an average glucosinolate concentration of 15.9 µmoles/g air dry.

Limitations/Risks

The results from this study are based on the consumption of expeller-extracted juncea meal for a 35 day period by growing pigs between 49 and 88 kg live weight. Further studies would be required to determine if there are any adverse effects of feeding juncea meal at up to 18 % for a longer period of time (i.e during both the grower and finisher period) or to animals of a younger age. Given the potential for variation in juncea meal glucosinolate concentration due to differing growing conditions and/or post harvest oil extraction methods, careful monitoring of the total glucosinolate concentration is recommended prior to animal feeding to assess the risk of feed aversion and optimise dietary inclusion concentrations.

Recommendations

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

- Preliminary results suggest that expeller extracted juncea meal may be included in diets for grower pigs at concentrations of up to 18 % without adversely affecting growth performance.
- Monitoring of the total glucosinolate concentration in Juncea meal is recommended prior to animal feeding to assess the risk of feed aversion and optimise dietary inclusion concentrations.
- Further studies may be warranted to confirm the maximum inclusion concentration in pigs housed in groups and offered the juncea meal for a longer period of time (i.e. during both the grower and finisher period).
- The feeding of expeller-extracted juncea meal to weaner pigs would not be recommended at this present time given the likelihood of depressed feed intakes. Further research and/or the development of lower glucosinolate cultivars of juncea meal would be required.
- Based upon the results of this experiment and other pig growth studies, it is recommended that the maximum inclusion level of juncea meal in commercial grower/finisher diets be limited to levels in which the total glucosinolate concentration in the complete diet does not exceed about 2.0 mmol/kg diet.
- Further discussions are required between commercial nutritionists, Smorgon Fuels and the research team to determine the economic value of juncea meal.

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References

Association of Official Analytical Chemists (AOAC) (1998) 'Official methods of analysis.'16th edn. (Association of Official Analytical Chemists: Washington, DC).

Corino C, Baldi A, Bontempo V (1991) Influence of low-glucosinolate rapeseed meal on performance and thyroid hormone status of heavy pigs. *Animal feed Science and Technology* 35, 321-331.

Jensen CR, Mogensen VO, Mortensen G, fieldsend JK, Milford GFJ, Andersen MN, Thage JH (1996) Seed glucosinolate, oil and protein contents of field-grown rape (*Brassica napus L.*) affected by soil drying and evaporative demand. *Field Crops Research* 47, 93-105.

King RH, Eason PJ, Kerton DJ, Dunshea FR (2001) Evaluation of solvent-extracted canola meal for growing pigs and lactating sows. *Australian Journal of Agricultural Research* 52, 1033-1041.

Mullan BP, Pluske JR, Allen J, Harris DJ (2000) Evaluation of Western Australian canola meal for growing pigs. *Australian Journal of Agricultural Research* 51, 547-553.

Newkirk RW, Classen HL, Tyler RT (1997) Nutritional evaluation of low glucosinolate mustard meals (*Brassica juncea*) in broiler diets. *Poultry Science* 76, 1272-1277.

Roth-Maier DA, Bohmer BM, Roth FX (2004) Effects of feeding canola meal and sweet lupin (*L. luteus, L.angustifolius*) in amino acid balanced diets on growth performance and carcass characteristics of growing-finishing pigs. *Animal Research* 53, 21-34.

Schone F, Kirchheim U, Schemann W, Ludke H (1996) Apparent digestibility of high-fat rapeseed press cake in growing pigs and effects on feed intake, growth and weight of thyroid and liver. *Animal feed Science and Technology* 62, 97-110.

Schone F, Leiterer M, Hartung H, HJahreis G, Tischendorf F (2001) Rapeseed glucosinolates and iodine in sows affect the milk iodine concentration and the iodine status of piglets. *British Journal of Nutrition* 85, 659-670.

Tripathi MK, Mishra AS (2007) Glucosinolates in animal nutrition: A review. *Animal feed Science and Technology* 132, 1-27.

Zijlstra RT, Hickling DR, Patience JF (2005) Comparison of voluntary feed intake and growth performance between grower pigs fed diets containing either mustard meal or canola meal. *Council Research News, Prairie Swine Centre*