Glucosinolate content of Rapeseed meal and the Nutritive Value of Pig Feeds

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Introduction

The protein of rapeseed meal has a well balanced amino acid profile for pigs and, in the abscence of antinutritive factors, would be expected to result in animal performance comparable to that obtained with diets containing soyabean meal. Principal among the antinutritive factors present which have historically limited the use of RSM in pig diets are a group of compounds known as glucosinolates. These sulphur containing compounds may be goitrogenic and/or hepatotoxic and additionally produce volatile and pungent hydrolysis products, resulting in reduced palatability of diets.

EC policy has been formulated which will ensure that newer varieties known as "double low" with reduced glucosinolate content become the dominant rapeseed crop in Europe. To qualify as a double low crop the seed must at present have a glucosinolate level of less than 35 umol/g but in the near future this will be reduced to 20 umol/g. A glucosinolate level of 20 umol/g in the seed is equivalent to 30 umol/g in the extracted meal a level at which it is expected that detrimental effects on pigs will be much reduced.

To establish if this will indeed be the case the Ministry of Agriculture, Fisheries and Food is funding a Nutrition research programme in which the University of Newcastle upon Tyne is participating. This paper presents outline results from the first year of this project at Newcastle.

Trial 1 Evaluation by rat metabolism study of Low Glucosinolate and high Glucosinolate Rapeseed meals

Two rapeseed meals (RSM) were purchased for use in pig growth trials, they contained 5 umol (LGRSM) and 137 umol (HGRSM) of glucosinolates per gramme of meal. A preliminary step was to

evaluate these two meals with rats to assess their biological values (BV's) as fed and perhaps more importantly the underlying BV's of the protein when the glucosinolates present in the meal were removed with 70% aqueous methanol (XLGRSM and XHGRSM). A futher refinement was to add back the extracted gluocosinolates in a crossover type of experiment, ie. the extract from the HGRSM was added to extracted LGRSM and vice versa. These products were used to formulate rat diets in which all dietary protein was provided by the test material and these diets were fed to rats of 100g initial weight in a metabolism trial. Details of materials and animal performance are given in Table 1.

Table 1. Biological value of rapeseed protein and organ weights of rats fed diets containing different amounts of glucosinolates.

	LGRSM	XLGRSM	XLGRSM + HGRSM ext.	HGRSM	XHGRSM	XHGRSM + LGRSM ext.	SOYA BEAN MEAL (SBM)	SED	Sig
Glucosinolate content of diet	Trace	0.00	31.2	32.8	8.7	8.1	0.00		
Thyroid weight (mg/100g LW)	9.31^{a}	8.14^{a}	21.84^{b}	26.78^{b}	10.62^{a}	9.36^{a}	10.71^{a}	2.21	***
Liver weight (g/100g LW)	4.06^{ab}	3.84^{a}	5.16^{c}	4.92^{c}	4.87^{c}	4.30^{b}	3.94^{ab}	0.208	*
BV	0.830^{bc}	0.936^{d}	0.510^{a}	0.748^{b}	0.875^{cd}	0.875^{cd}	0.872	0.046	*

From this trial it was apparent that a significant reduction in biological value could be accounted for by the prescence of glucosinolates in the diet (ie. 0.748 for HGRSM compared with 0.875 for extracted HGRSM). Secondly it was seen that the protein was of high quality and that the two rapeseed meal proteins were of similar BV when glucosinolates were removed (0.936 for XLGRSM and 0.875 for XHGRSM). Extract from HGRSM had a dramatic effect on BV when added to XLGRSM, it is thought that this may have been due to the prescence in the extract of gluocinolate hydrolysis products which may be more toxic than the glucosinolates themselves (Sarwar, et al, 1981). Both thyroid and liver weights were significantly increased when diets containing appreciable quantities of glucosinolate were consumed.

Trial 2 Effect of Dietary Glucosinolate level on growing pig performance

The previous rat study demonstrated that glucosinolates can reduce the biological value of rapeseed protein, furthermore it also indicated that physiological changes were taking place in the animal as a response to the prescence in the diet of glucosinolates. A pig growth study was initiated to investigate the consequences for commercial pig production of feeding diets containing glucosinolates. To ensure that only the effect of glucosinolate levels was measured in the pigs the experiment was designed to have dietary inclusion of RSM fixed at 150 g/kg but a range of glucosinolate levels from 0.75 to 10.73 umol/g. This was achieved by blending the LGRSM and HGRSM evaluated in the rat trial to give diets containing the desired level of glucosinolates. A soyabean based control diet was also fed and diet specification was DE 13.30 MJ/kg, CP 182.5 g/kg and lysine 12 g/kg for all diets. Feeding level was a weight based scale estimated to provide around 95% of ad libitum intake

The results presented in Table 2 demonstrate that there was no effect on commercial performance of pigs growing from 30 to 75 kg LW when fed any of the diets. Physiological changes were occurring as evidenced by the enlarged thyroids and livers. Under truly ad lib feeding systems it may be found that diets containing high levels of glucosinolate will not be consumed so readily as those with a lower content. A second point to note is that the RSM inclusion level of 150 g/kg was relatively low and it may be that at higher inclusion levels the findings of this experiment may not hold. Work is currently being undertaken to examine these questions.

Table 2. Effect of dietary glucosinolate content an pig performance, carcass composition and organ weights.

	Diet glucosinolate content (umol/g)							
	0.00	0.75	3.24	5.74	8.25	10.75	SED	Sig.
ADG	746	818	767	781	741	757	35.4	NS
FCR	2.54	2.25	2.45	2.38	2.48	2.48	0.111	NS
KO%	0.744	0.730	0.741	0.731	0.737	0.729	0.0072	NS
C (mm)	6.2	6.6	7.8	6.6	7.8	6.1	0.90	NS
K (mm)	12.8	11.2	14.1	11.5	11.8	10.3	1.30	NS
Liver weight (g)	1395^{a}	1455^{a}	1468^{a}	1624^{b}	1639^{b}	1688^{b}	66.0	*
Thyroid weight (g)	6.98^{a}	6.79^{a}	8.92^{b}	9.55^{b}	9.71^{b}	8.86^{b}	0.982	*

Means within the same row with different superscripts are significantly different ($P<0.05$).

Trial 3 "Triple Low" Rapseed meal for starter pigs

Varieties of oilseed rape with a lower content of glucosinolate are being produced commercially which are termed "double low". With the exception of lowered glucosinolate content their composition is very similar to that of the traditional single low varieties, the extracted meal having CP around 360 g/kg, oil 20 g/kg and fibre 120 g/kg. There are presently varieties under development which have both a lower fibre and tannin content in addition to low glucosinolate levels. These varieties are commonly referred to as "triple low" and can generally be distinguished by their yellow seed coat.

Newly weaned pigs do not in general perform well when fed diets containing appreciable amounts of double low rapeseed meal. Possible reasons for this have been proposed including fibre level, tannin content, sinapine content and/or glucosinolate level. Triple low varieties may alleviate the problem by virtue of their lower fibre and tannin contents. This trial was designed to determine the response of newly weaned pigs growing from 8 to 20 kg liveweight, to diets in which soyabean meal had been incrementally replaced by an isonitrogenous quantity of triple low rapeseed meal.

Methodology

A series of diets containing 100, 200, 300 and 400g triple low RSM and 50g fishmeal per kg were produced and fed to mixed sex groups of 8 pigs between 6 and 7kg initial LW. A diet containing 200g double low RSM and a control SBM based diet were also fed.

All diets were formulated to be isoenergetic and isonitrogenous with DE of 14.6 MJ/kg, CP 216 g/kg and lysine 13 g/kg. Copper (170 mg/kg) and Tylosin (40 mg/kg) were included in all diets. Feeding was ad libitum from hoppers and the triple low RSM used had a glucosinolate content of 3 umol/g.

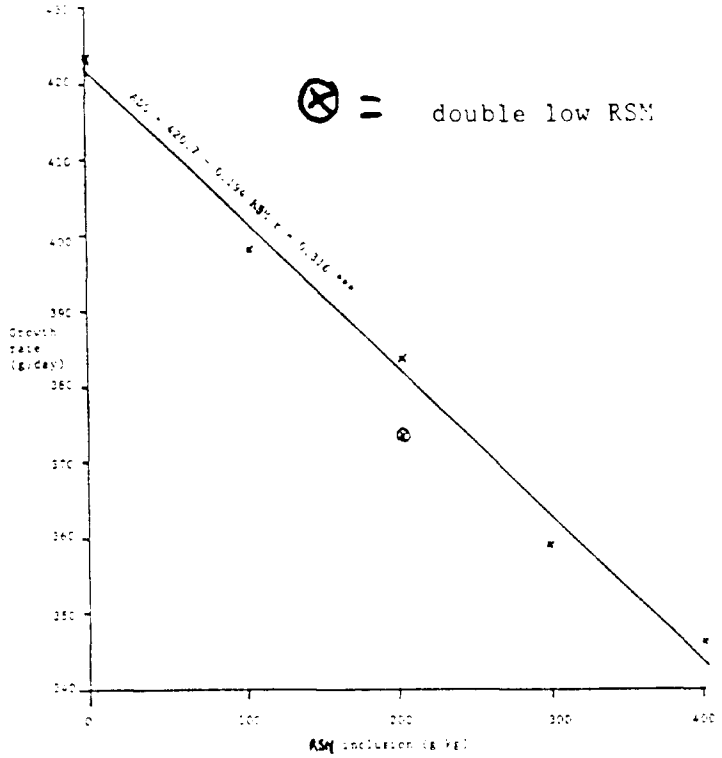
Results

Table 3. Average daily gain (ADG) and Feed Conversion Ratio (FCR) of starter pigs fed diets containing Triple Low RSM

	Control	Triple Low RSM				Double low RSM		
RSM inclusion (g/kg)	0	100	200	300	400	200	SED	Sig
ADG	423^{a}	398^{ab}	384^{bc}	359^{cd}	346^{d}	376^{bd}	17.26	*
FCR	1.46^{a}	1.47^{a}	1.48^{a}	1.58^{ab}	1.57^{ab}	1.66^{b}	0.061	*

A significant reduction in performance was observed (Table 3). The double low RSM included in the trial resulted in a significantly poorer FCR than Triple low included at the same level. A highly significant negative regression between ADG and rapeseed meal inclusion level was obtained (Figure 1). These results indicate that further nutritional studies must be done to find out what component or components of triple low rapeseed meal causing the reduction in growth rate observed in this experiment.

Figure 1. Regression of daily gain with triple low rapeseed meal inclusion in the diet



Trial 4 Evaluation of Rapeseed varieties grown on two sites

The greatest differences in glucosinolate content between samples of rapeseed are attributed to variety. As part of a collaborative project with agronomists at Newcastle University and Rothamsted experimental station (AFRC), small quantities of rapeseed of known variety, grown under defined agronomic conditions at two sites were available. It was decided that these materials should be evaluated, in part, by animal experimentation; however, the small quantities (approximately 10kg) of each material available precluded feeding to pigs and a rat trial was instigated.

Materials and Methods

Four varieties: Ariana, Bienvenu, Cobra, and PBI3 were grown at Rothamsted experimental station Hertfordshire and two varieties Ariana and Bienvenu were grown under the same agronomic conditions at the Newcastle University research farm, Northumberland. Samples of 2kg were subjected to extraction of oil in the laboratory. The resultant extracted meals had the following composition.

Table 4. Chemical composition and glucosinolate content of extracted rapeseed meals used in variety experiment.

		PBI3 (Roth)	Cobra (Roth)	Ariana (NCL)	Ariana (Roth)	Bienvenu (Roth)	Bienvenu (Ncl)
g/kg	CP	357	332	377	353	360	346
	EE	49.6	34.0	36.6	40.6	42.9	42.0
Total glucosinolate (u mol/g)		17.6	17.9	30.4	38.7	52.2	52.9

Seven semi synthetic diets were produced, six containing the rapeseed meals characterised in Table 4 as the only protein and a seventh containing albumin. All diets were formulated to contain 100g CP/kg. Five individually housed rats (of approximately 100 gLW) were fed each diet and total faeces and urine collections made. At the end of the collection period rats were killed and tissue samples taken.

Results

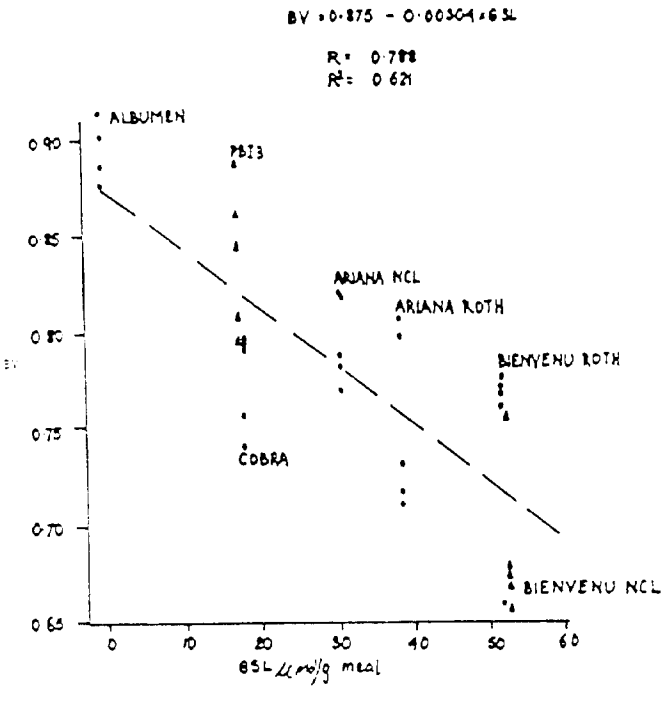
Table 5. Biological value of rapeseed protein and organ weights of rats fed diets containing RSM from different varieties.

	Albumen	PBI3 (Roth)	Cobra (Roth)	Ariana (Ncl)	Ariana (Roth)	Bienvenu (Roth)	Bienvenu (Ncl)	SIG
Glucosinolate content umol/g meal	0.0	17.6	17.9	30.4	38.7	52.2	52.9	
T4 ug/dl plasma	4.66^{d}	3.28^{c}	2.28^{b}	1.33^{ab}	0.97^{ab}	0.73^{a}	0.81^{a}	*
BV	0.891^{a}	0.840^{ab}	0.776^{c}	0.797^{bc}	0.753^{c}	0.748^{c}	0.686^{d}	*
Aspartamine Amino Transferase	31.2^{b}	52.7^{a}	51.7^{a}	37.4^{ab}	50.7^{a}	55.5^{a}	52.1^{a}	*
Liver weight(g)	4.24^{d}	5.06^{c}	5.56^{ac}	5.68^{ab}	5.86^{a}	5.96^{a}	6.09^{a}	*

There were significant differences in BV both between varieties and between sites, although the site effect was not consistent. A significant regression of BV with glucosinolate content of the meal was obtained (Figure 2).

Biological value of the protein in PBI3 was significantly greater than all other meals with the exception of Ariana from Newcastle. This cannot be entirely attributed to its low glucosinolate level since Cobra with the same glucosinolate content had a significantly lower BV for its protein. Individual glucosinolate ratios for the different meals were similar.

Figure 2. Regression of Rapeseed protein BV with Glucosinolate content of the meal for Rapeseed varieties from two sites.



Plasma T4 was lower for all rapeseed diets than for the albumin control and there was a significant regression with glucosinolate content of the meal (T4 = 4.197 - 0.071 x glucosinolate content umol/g r = 0.89). AAT was in general elevated by rapeseed meal in the diet but this does not appear to be due to the level of glucosinolate in the meal. Livers became significantly enlarged as the level of glucosinolate in the meal increased.

The results of this trial demonstrate that varietal differences in nutritive value are not entirely due to glucosinolate content. The possibility exists that sinapine or tannins may be of importance and analytical techniques to investigate this are being refined. It is proposed to scale up this experiment to a pig study in the near future.

Conclusions

1. Glucosinolates in rapeseed meal can reduce biological value of rapeseed protein.
2. Physiological changes (principally thyroid and liver enlargement) occur in both rats and pigs where fed diets containing glucosinolates.

3. Glucosinolate levels of up to 10.75 umol/g diet do not appear to to be detrimental to growth rate, feed conversion or carcass composition of commercial pigs under a feeding regime restricted to 95% of estimated ad libitum intake.
4. Growth rates of newly weaned pigs were significantly reduced when either triple low RSM or double low RSM was included in diets.
5. Differences between rapeseed varieties in the biological value of their protein cannot be entirely explained by glucosinolate levels.

Future Work

Work at Newcastle is presently being planned:

1. To further investigate varietal differences which cannot be attributed to glucosinolate content.
2. To determine the effect on voluntary feed intake of diets containing graded levels of glucosinolate, fed to both newly weaned and growing pigs.
3. To investigate the effect of harvesting date and technique on glucosinolate content and nutritive value of rapeseed varieties.

Reference

Sarwar, G., Bell, J.M., Sharby, T.F. and Jones, J.D. (1981) Nutritional evaluation of meals and meal fractions derived from rape and mustard seeds. Canadian Journal of Animal Science 61 719-733