RAPESEED MEAL AS A DIETARY PROTEIN SUPPLEMENT FOR FINISHING PIGS

B.P. Gill

The Scottish Agricultural College - Aberdeen,
581 King Street, Aberdeen, Scotland AB9 IUD

INTRODUCTION

The commercial extraction of oil from rapeseed leaves a meal which is a rich source of protein. The protein is of high biological value (Ballester et al. 1977; Sauer et al. 1982), a feature which is unusual for proteins of vegetable origin. Common with other crude vegetable protein supplements, rapeseed meal has an array of antinutritive and potentially toxic factors, the most significant of which are the water soluble glucosinolates (VanEtten and Tookey 1983; Bell 1984). These are concentrated in the meal, by nearly a factor of two, due to oil extraction. Glucosinolates release goitrogenic and toxic compounds following hydrolysis by the enzyme myrosinase which is found in rapeseed (Fenwick et al. 1983) and which may be produced by gut microbes (Oginsky et al. 1965; Nugon-Baudon et al. 1990). Hydrolysis may take place during oil extraction or following ingestion by the animal (Marangos and Hill 1974).

High glucosinolate content has previously constrained the inclusion of rapeseed meal in pig feeds to levels rarely exceeding five percent of the total diet. Selection of improved varieties may now have reduced glucosinolates concentrations below a critical level which enables formulations to accept rapeseed meal without constraints. Opportunities for using rapeseed meal may have been further assisted by the recent introduction of commercially selected Brassica campestris varieties. These are considered to have lower concentrations of other antinutritive factors including glucosinolates.

The aim was to evaluate the scope for completely replacing soyabean meal (SBM) with rapeseed meal (RSM) as a sole dietary protein supplement for finishing pigs.

MATERIALS AND METHODS

Sixty Large White x (Large White x Landrace) pigs averaging 39.4kg (s.e.m. 0.24) were allocated to one of 3 dietary treatments (Table 1).

Solvent extracted RSM from either B. napus (brown hulled, var. Topas) or B. campestris (yellow hulled, var. unnamed) seed was used to completely replace SBM in a control diet. All diets were formulated to provide 13 MJ digestible energy (DE) and 6g ileal digestible lysine per kg. Diets were formulated using values from proximate analyses of RSM (Table 1) and book values for other ingredients. Published apparent ileal digestible lysine values were used for barley, SBM and RSM (Sauer et al. 1982; Rowan and Lawrence 1986; Partridge et al., 1987; NRC 1988). Adjustments in DE and lysine were made by additions of soyabean oil and lysine hydrochloride.

Pigs were housed in groups of 6 (3 entire males and 3 females) and fed individually twice daily to a scale which provided 90% of their predicted voluntary intake using DE (MJ/d) = $50(1-e^{-0.0204W})$, where W is live weight in kg (ARC 1981). Pigs were individually weighed on 3 consecutive days at the start and end of the experiment. Feed allowances were adjusted weekly according to individual pig weights. All feed inputs and refusals were recorded. Water was available ad libitum from nipple drinkers. Pigs were slaughtered when they reached approximately 90 kg live weight and commercial carcass evaluation data was retrieved from the abbatoir for statistical analysis.

Table 1. Formulation of the experimental diets

	Diet		
	A	B	C
Ingredients (g/kg)			
Barley	791.0	646.0	692.6
Rapeseed meal			
B. napus (var. Topas)	-	312.6	-
B. campestris (var. unnamed)	-	-	268.2
Soyabean meal	172.5	-	-
Soyabean oil	6.4	19.3	15.9
Lysine HCl	-	1.1	1.2
Salt	6.2	6.1	6.1
Dicalcium phosphate	12.8	1.2	2.2
Limestone	8.6	11.2	11.3
Vitamin and mineral mix	2.5	2.5	2.5

Analysis of Rapeseed and Rapeseed Meal

Samples of whole seed and solvent extracted RSM from both B. napus and B. campestris varieties of oilseed rape used in this experiment were subjected to standard proximate analysis and assayed for individual glucosinolates by high performance liquid chromatography (HPLC) using published methods (Sang et al. 1984; Spinks et al. 1984). Results are presented in Table 2.

Statistical Analysis

Experimental data were treated as a Randomised Complete Block Design and subjected to Analysis of Variance (Snedecor and Cochran, 1967).

RESULTS

Performance and carcass measurements of pigs fed the 3 diets are given in Table 3. Feed intake, growth rate and conversion of feed to gain were significantly reduced by the replacement of SBM with RSM ($P<0.05$). There were no significant differences ($P>0.05$) in intake or growth rate between pigs fed diets containing RSM extracted from either B. napus or B. campestris seed. Supplementation with RSM from B. campestris seed gave significantly better ($P<0.001$) conversion of feed to gain than with RSM from B. napus seed. Fat thickness (P2) of pigs fed RSM diets was significantly less ($P<0.05$) than of the control SBM group. There were no significant ($P>0.05$) sex x treatment interactions in performance and carcass measurements.

Table 2. Proximate composition and individual glucosinolates in rapeseed meal and in whole seed from which the meal was extracted

	Seed		Meal	
	B. napus (var. Topas)	B. campestris (var. unnamed)	B. napus	B. campestris
Proximate analyses (g/kg DM)				
Dry matter	919.4	917.0	873.6	856.7
Crude protein	202.4	225.3	351.9	398.0
Crude fibre	84.8	83.0	148.2	145.7
Ether extract	460.8	451.3	33.2	21.2
Ash	43.2	48.6	84.0	87.2
Acid detergent fibre	141.4	100.7	269.2	176.7
Individual glucosinolates (μmoles/g DM)				
Gluconapin	2.24	1.70	1.21	0.51
Glucobrassicanapin	0.84	1.03	0.24	0.25
Progoitrin	6.01	2.85	2.78	0.81
Gluconapoleiferin	0.76	0.92	0.28	0.42
Gluconasturtiin & 4-Methoxyglucobrassicin	0.12	0.15	ND(1)	ND
4-Hydroxyglucobrassicin	0.34	ND	ND	ND
Glucobrassicin	0.10	ND	ND	ND
Total glucosinolates				
HPLC	10.41	6.65	4.51	1.99
Glucose release(2)	8.35	4.98	3.90	1.20

(1) Not detected
(2) Using published method (VanEtten et al. 1974).

Table 3. Feed intake, daily gain and feed conversion and carcass measurements of pigs according to dietary treatment

	Diet				
	A	B	C	P	s.e.d.(1)
Initial weight (kg)	39.14	39.01	39.94	NS	0.576
Final weight (kg)	91.52(a)	89.26(b)	89.90(a)	<0.05	0.852
Feed intake (kg/day)	2.36(a)	2.29(b)	2.23(b)	<0.01	0.033
Live-weight gain (kg/day)	1.00(a)	0.90(b)	0.91(b)	<0.001	0.024
Feed conversion	2.38(a)	2.56(b)	2.44(c)	<0.001	0.032
Back fat(2) (P2, mm)	13.99(a)	12.33(b)	12.79(b)	<0.05	0.543
Dead weight (kg)	70.09(a)	68.10(b)	69.49(a)	<0.05	0.665
Killing out %	76.59	76.30	77.31	NS	0.487

(a,b,c) Means in the same row with a common superscript do not differ significantly (P>0.05)
(1) Standard error of the difference between two means
(2) Measured over the Longissimus dorsi using a probe inserted 6.5cm from the mid-line and level with the head of the last rib (MLC 1985).

DISCUSSION

In this study rapeseed meal, when used as the sole dietary protein supplement, gave satisfactory growth rates and conversion of feed to body gain in finishing pigs. This correlates with work in rats which has demonstrated the potentially high nutritional value of isolated and detoxified rapeseed protein (Ballester et al. 1977; Sauer et al. 1982). In pigs, studies with commercially extracted meals indicate that the apparent ileal digestibility of indispensable amino acids in RSM are between 10 and 15% lower than in SBM (Sauer et al. 1982; Rowan and Lawrence, 1986; Partridge et al. 1987). Despite these differences, RSM provides essential amino acids in relative proportions which meet the various published estimates of the ideal protein balance for pigs (ARC 1981; NRC 1988).

Although adjustments in formulations were made for differences in protein digestibility, diets containing RSM gave reduced intakes and growth rates and poorer conversion of feed to body gain than for the SBM control diet. It is possible that evaluations of RSM by short-term digestibility experiments are unable to completely account for any undesirable effects of feeding RSM over longer periods, as in performance trials. Cumulative glucosinolate toxicity, even at low concentrations in improved varieties, could be one of these effects. In this respect, the presence of antinutritive factors including residual glucosinolates and their absolute levels in different meals could be of practical importance. For example in the current experiment, the conversion of feed to gain was significantly better ($P<0.05$) with RSM extracted from B. campestris seed than from B. napus seed. Several factors could explain this difference. These may include a higher total glucosinolate content in B. napus RSM and intrinsic differences in fibre composition which may influence PER (protein efficiency ratio) and nutrient digestibility (Ballester et al. 1973 and 1977; Sauer et al. 1982; Bell and Shires 1982).

It is not possible to discuss the significance of any variation in the concentration of individual glucosinolates found in the two meal types, because of the confounding effects of other factors. It is reasonable to assume from other studies (Vermorel et al. 1986 and 1988) that the lower progoitrin content of B. campestris RSM could be relevant to its enhanced feeding value. Reductions in gluconapin content could be of additional importance, based on the results of experiments investigating the effects of individual glucosinolates in rats (Vermorel et al. 1986). The effects of indole glucosinolates are less clear though toxicological investigations with glucobrassicin, which is proportionately higher in low-glucosinolate varieties, suggest that they are relatively innocuous (Vermorel et al. 1986). Nevertheless, interpretation of the results of growth trials with extracted meals, in the context of work with isolated glucosinolates, is often difficult because the response of animals to the two materials can be surprisingly different.

Finally, contrary to expectation, the commercial extraction of oil from the seed led to a reduction in total glucosinolate content in the meals as established by HPLC and glucose release. This is probably explained by the hydrolysis of intact glucosinolates to other compounds (eg oxazolidinethiones, isothiocyanates and nitriles) not detected by these procedures. This is supported by the absence of indole-glucosinolates in the meals, which are particularly sensitive to processing conditions (Fenwick et al. 1986).

CONCLUSIONS

When used as the sole dietary protein supplement, RSM can give satisfactory rates of intake, growth and feed conversion in finishing pigs. Losses in performance compared with SBM based diets and any difference between the types of RSMs used may relate to the presence of antinutritive factors including residual glucosinolates. Growth studies are useful in that they allow the evaluation of RSMs over longer periods when the effects of toxic factors can be observed.

Acknowledgements

The author is grateful to Mr A. G. Taylor for his technical assistance with the growth experiment and is indebted to Dr M. J. Allison and Dr D. W. Griffiths, Scottish Crop Research Institute, Invergowrie, for identification and analysis of individual glucosinolates by HPLC.

REFERENCES

THE AGRICULTURAL RESEARCH COUNCIL. 1981. The Nutrient Requirements of Pigs. Commonwealth Agricultural Bureaux, Slough. p. 39.

BALLESTER, D., KING, J., VERA, P., BRUNSER, O., YAÑEZ E. and MONCKEBERG, F. 1977. Toxicity of water extracted rapeseed meal in the rat. J. Sci. Fd. Agric. 28: 855-862.

BALLESTER, D., RODRIGUEZ, B., ROJAS, M., BRUNSER, O., REID, A., YAÑEZ, E. and MONCKEBERG, F. 1973. Rapeseed meal IV. Continuous water extraction and short-term feeding studies in rats with the detoxified product. J. Sci. Fd. Agric. 24: 127-138.

BELL, J.M. 1984. Nutrients and toxicants in rapeseed meal: A review. J. Anim. Sci. 58: 996-1010.

BELL, J.M. and SHIRES, A. 1982. Composition and digestibility by pigs of hull fractions from rapeseed cultivars with yellow or brown seed coats. Can. J. Anim. Sci. 62: 557-565.

FENWICK, G.R., HEANEY, R.K. and MULLIN, W.J. 1983. Glucosinolates and their breakdown products in food and food plants. In: CRC Critical Reviews in Food Science and Nutrition. CRC Press, Boca Raton, Fl. 18: 123-201.

FENWICK, G.R., SPINKS, E.A., WILKINSON, A.P., HEANEY, R.K. and LEGOY, M.A. 1986. Effect of processing on the antinutritive content of rapeseed. J. Sci. Fd. Agric. 37: 735-741.

MARANGOS, A. and HILL, R. 1974. The hydrolysis and absorption of thioglucosides of rapeseed meal. Proc. Nutr. Soc. 33: 90A.

THE NATIONAL RESEARCH COUNCIL. 1988. Nutrient Requirements of Swine. 9th ed. National Academy Press, Washington, D.C. p. 62.

NUGON-BAUDON, L., RABOT, S., WAL, J.M. and SZYLIT, O. 1990. Interactions of the intestinal microflora with glucosinolates in rapeseed meal toxicity: First evidence of an intestinal Lactobacillus possessing a myrosinase-like activity In Vivo. J. Sci. Fd. Agric. 52: 547-559.

OGINSKY, E.L., STEIN, A.E. and GREER, M.A. 1965. Myrosinase activity in bacteria as demonstrated by the conversion of progoitrin to goitrin. Proc. Soc. exp. Biol. Med. 119: 360-367.

PARTRIDGE, I. G., LOW, A.G. and MATTE, J.J. 1987. Double-low rapeseed meal for pigs: Ileal apparent digestibility of amino acids in diets containing various proportions of rapeseed meal, fish meal and soya-bean meal. Anim. Prod. 44: 415-420.

ROWAN, T.G. and LAWRENCE, T.L.J. 1986. Ileal apparent digestibilities of amino acids, growth and tissue deposition in growing pigs fed low glucosinolate rapeseed meals. J. agric. Sci., Camb. 107: 493-504.

SANG, J.P., MINCHINTON, I.R., JOHNSTONE, P.K. and TRUSCOTT, R.J.W. 1984. Glucosinolate profiles in the seed, root and leaf tissue of cabbage, mustard, rapeseed, radish and swede. Can. J. Plant Sci. 64: 77-93.

SAUER, W.C., CICHON, R. and MISIR, R. 1982. Amino acid availability and protein quality of Canola and rapeseed meal for pigs and rats. J. Anim. Sci. 54: 292-301.

SNEDECOR, G.W. and COCHRAN, W.G. 1967. Statistical methods. 6th ed. Iowa State University Press, Ames.

SPINKS, E.A., SONES, K. and FENWICK, G.R. 1984. The quantitative analysis of glucosinolates in cruciferous vegetables, oilseeds and forage crops using high performance liquid chromatography. Fette-Seifen-Anstrichmittle. 86: 228-231.

VANETTEN, C.H., McGREW, C.E. and DAXENBICHLER, M.E. 1974. Glucosinolate determination in cruciferous seeds and meals by measurements of enzymatically released glucose. J. agric. Fd. Chem. 22: 483-487.

VANETTEN, C.H. and TOOKEY, H.L. 1983. Glucosinolates. In: CRC Handbook of Naturally Occurring Food Toxicants. M. Rechcigl (ed.). CRC Press, Boca Raton, Fl. pp. 15-30.

VERMOREL, M., HEANEY, R.K. and FENWICK, G.R. 1986. Nutritive value of rapeseed meal: Effects of individual glucosinolates. J. Sci. Fd. Agric. 37: 1197-1202.

VERMOREL, M., HEANEY, R.K. and FENWICK, G.R. 1988. Antinutritional effects of the rapeseed meals, Darmoor and Jet Neuf, and progoitrin together with myrosinase, in the growing rat. J. Sci. Fd. Agric. 44: 321-334.