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Rapeseed meal of low- and high-glucosinolate type fed to growing-finishing pigs

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Abstract. The nutritive value of five lots of rapeseed meal (RSM) from *Brassica campestris* or *B. napus* with different levels of glucosinolates (GL) was investigated in a digestibility and balance trial with a 5 × 5 Latin square design and in a growth trial with 140 growing-finishing pigs. The RSM's were prepared from the cultivars: Span-Torch, Sigga, Gulliver and Topas, and a heat-treated RSM was also studied, their total GL contents (μmol/g defatted meal) being 42, 11, 98, 27 and 8, respectively. Cv. Sigga had yellow hulls and a lower ADF content than the other cultivars. The hat-treated RSM had a reduced lysine content.

There were no significant ($P > 0.05$) differences in organic matter or crude protein digestibilities between the RSM's with different GL levels or the RSM's prepared from *B. campestris* and *B. napus,* when RSM was used as the only protein supplement at a level of 20—25 % in a barley-based diet. Heat treatment reduced the organic matter and crude protein digestibilities ($P < 0.01$). Nitrogen retention and protein utilization were lower ($P < 0.01$) on the diet supplemented with heat-treated RSM than on the diets with the other RSM's but otherwise there were no significant differences between them ($P > 0.05$).

In the growth trial supplementation with HGL-RSM Gulliver (14 % in diet) caused some palatability problems and this led to reduced performance ($P < 0.05$), but there were no differences between the other groups receiving 14—15 % RSM and the SBM control group ($P > 0.05$). The carcass quality was similar in all the groups. The weight of the thyroid gland was higher in the pigs receiving RSM than in the SBM controls, by 6—57 % ($P < 0.05$).

In the present study a fairly high RSM supplements from cultivars with a moderate high GL content could be used in the diet of growing pigs without impairing their performance, when the diet was formulated on the basis of the digestible nutrients of RSM. Heat-treated RSM, with protein of low rumen degradability, is of poor value in pig feeding due to the low digestibility and availability of its protein.

Index words: Rapeseed meal, glucosinolates, protein supplement, pig feeding, digestibility.

Introduction

In Finland, production of rapeseed is one of the most readily available means of increasing the domestic supply of protein of high biological value for animal feeding. Rapeseed, both *Brassica campestris* and *B. napus,* is the only oil seed suitable for commercial cultivation in the climatic conditions of this country and its production has increased rapidly over the past decade. Rapeseed meal (RSM) contains 35—40 % crude protein and RSM proteins have a well-balanced amino acid pattern, but their availability is rather low (Sauer et al. 1982). The antinutritional and toxic constituents of rapeseed are known greatly to restrict the utilization of RSM as a feed for monogastrics (Bell 1984). The fibre content of RSM is almost double that of soybean meal (SBM), which lowers the digestibility and feed value (Salo 1982).

The most important factor limiting the potential RSM as a protein supplement in pig feeding is the presence of glucosinolates (Rundgren 1983). Some of these are goitrogenic and others are potentially hepatotoxic, whilst the majority are volatile and have a strong bitter taste (Bell 1984). Meals prepared from rapeseed varieties with low or medium contents of glucosinolates are finding increased acceptance as a protein source in pig diets and are being used as a replacement for SBM (Alaviuhkola 1981, Salo 1982, Thomke et al. 1983, Thomke 1984). The breeding work directed towards reduction of the hull content may also make RSM more suitable for pig feed. Some studies have shown that RSM may totally or partially replace SBM in growing-finishing pig diets without adverse effects of performance, while other studies have shown that complete or partial substitution of RSM for SBM affects pig performance adversely (Rundgren 1983).

The present study was conducted to compare the nutrient digestibility of rapeseed meals with different levels of glucosinolates and their effects on the performance of growing-finishing pigs. One of the RSM's was heat-treated in order to obtain information on the nutritive value on the RSM with low rumen — degradable protein in pig feeding.

Materials and methods

Experimental feeds

Two of the feeds from *Brassica campestris* were of Finnish origin: a commercial high-glucosinolate rapeseed meal (HGRSM) prepared from cv. Span-Torch and a low-glucosinolate rapeseed meal (LGRSM) prepared from cv. Sigga. Two lots of *B. napus* meal were obtained from Sweden: HGRSM cv. Gulliver and LGRSM cv. Topas. One lot of *B. napus* meal was processed in Denmark to reduce the rumen degradability of the protein. The seeds were flaked, cooked, expelled through a press, extracted with hexane, desolvetized and toasted. The composition of the glucosinolates was as follows:

	B. campestris		*B. napus*		
	Span	Sigga	Gulliver	Topas	Heat treat.
Gluconapin	13.8	3.8	25.9	7.0	3.2
Glucobrassicanapin	11.2	2.2	5.8	2.2	2.1
Progoitrin	15.0	4.6	64.0	17.4	3.1
Napoleiferin	2.2	0.5	2.2	0.5	0

Concentrations expressed as μmol/g defatted meal
Analysis made at University of Technology, Department of Chemistry by courstesy of Dr. Anneli Hase.

Digestibility and balance trial

The experiment involved five isonitrogenous, 16 % crude protein diets, in which RSM's of HG or LG types were used as protein supplements. The diets were enriched with 40 g/d mineral mixture and 15 g/d vitamin mixture and had the following composition:

Diet	Barley	RSM	Starch
1. HGRSM Span-Torch	75.0	25.0	0.0
2. LGRSM Sigga	75.0	25.0	0.0
3. HGSRM Gulliver	75.0	21.9	3.1
4. LGRSM Topas	75.0	20.2	4.8
5. LGRSM Heat-treat.	75.0	21.5	3.5

Five crossbred barrows, weighing 29 kg initially and 71 kg finally, were rotated through five successive feeding periods in a 5 × 5 Latin square arrangement. One pig was fed on only barley plus minerals, to obtain the basal diet digestibilities. Each period comprised 6 days of adjustment and 6 days of faecal and urine collection, as described by Näsi (1984). The coefficients of the apparent digestibility of the nutrients and the nitrogen balance were calculated for each diet and, using the difference method, for each RSM, too. The digestibility coefficients were analysed statistically as a Latin square design.

Growth trial

A hundred and forty cross-bred Landrace and Large White pigs averaging 25 kg live weight were allotted to five experimental groups on the basis of litter origin, sex and initial live weight. Each group consisted of 14 replicates of two pair-fed pigs. The diets were formulated to contain 135 g DCP/FU and minerals and vitamins according to the requirements (Salo et al. 1982). The five formulas, in which the rapeseed meals replaced soybean meal had the following dietary composition:

	B. campestris		*B. napus*		
Ingredients	0-rape	00-rape	0-rape	00-rape	Control SBM
Barley	77.5	77.5	78.5	78.5	82.5
HGRSM Span-Torch	15.0	—			
LGRSM Sigga	—	15.0	—	—	—
HGRSM Gulliver	—	—	14.0	—	—
LGRSM Topas	—	—	—	14.0	—
Soybean meal	1.0	1.0	1.0	1.0	11.0
Fish meal	3.0	3.0	3.0	3.0	3.0
Min. vit. mix.	3.5	3.5	3.5	3.5	3.5
FU/kg feed	0.926	0.933	0.930	0.931	0.964
DCP/FU, g	137	134	138	140	136

The pigs were fed according to a weight-based restricted feeding scale (Salo et al. 1982). Individual live weights and feed consumption on a pen basis were recorded at weekly intervals. The pigs were sent to slaughter when they reached 95 kg live weight. The carcass evaluation was made by measuring the ratio of lean to fat, the colour of the lean and pH. The thyroid weights were also determined on the recovered portion of 50—67 % of the pigs in the different groups.

Results and discussion

The total glucosinolate levels (μmol/g defatted meal) of the rapeseed meals investigated in this study were: *B. campestris* — Span-Torch 42.2 (HGRSM) and Sigga (LGRSM) 11.1 and for *B. napus* — Gulliver 97.9 (HGRSM), Topas 27.1 (LGRSM) and heat treated RSM 8.4. The Finnish commercial RSM originates mainly from *B. campestris* cultivars Span, Torch and Emma, which have much lower total glucosinolate contents less than *B. napus* HG types. The content of nitrils was 1.7 μmol/g in meal from Sigga and 2.1—2.6 in the other RSM's.

In the RSM's originating from *B. campestris* the crude protein content was 7 % units lower and the fat left in solvetizing was 10 %, the process thus differing between the various RSM's (Table 1). Crude fibre was at the same level in all the RSM's except cv. Topas, in which it was a little lower. Cv. Sigga is a yellow thin-coated type, but had no difference in crude fibre (Table 1). However, the analysis for acid detergent fibre and acid detergent lignin showed that Sigga had one quarter less ADF and only half the ADL value than the others. The hulls from yellow cultivars contain less crude fibre than those from the dark cultivars (Stringham et al. 1974, Bell and Shires 1982). The yellow hulls have a higher amount of polysaccharides and less polyphenols than the dark hulls (Theander et al. 1977).

The amino acid composition was fairly similar in the different RSM's (Table 1). Heat-treated RSM had a reduced lysine content, the available lysine being especially low, 2.6 g/16 g N vs. 4.1—4.2 in the other RSM's. The rumen degradability of the heat-treated RSM

Table 1. Chemical composition of rapeseed meals from different cultivars.

	B. campestris		*B. napus*		
	HGRSM Span-Torch	LGRSM Sigga	HGRSM Gulliver	LGRSM Topas	LGRSM Heat treated
Dry matter %	88.4	89.6	89.3	89.0	86.3
Ash, %	7.3	7.3	7.4	7.4	7.5
Crude protein, %	35.2	34.0	39.6	43.1	41.9
True protein, %	30.9	31.3	33.2	39.5	38.6
Ether extract, %	7.9	12.3	1.9	3.0	4.6
Crude fibre, %	15.7	16.7	16.1	12.6	15.1
Nitrogen free extract, %	33.9	29.8	35.0	34.0	30.9
Acid detergent fibre, %	21.4	15.1	20.9	18.9	21.7
Neutral detergent fibre, %	24.7	30.0	26.0	24.8	30.5
Acid detergent lignin, %	10.0	4.6	9.4	9.1	11.0
Total glucosinolates μmol/g	42.2	11.1	97.9	27.1	8.4
Progoitrin, μmol/l	15.0	4.6	64.0	17.4	3.1
Tannin, %	1.4	1.7	1.6	1.8	1.5
Amino acids, g/16 g N					
Alanine	4.3	4.1	4.2	4.2	4.1
Arginine	6.6	6.3	6.9	7.2	6.3
Aspartic acid	6.5	7.8	6.5	6.9	7.9
Cystine	1.3	1.5	1.7	1.4	1.2
Glutamic acid	20.3	20.2	20.0	20.6	18.3
Glycine	5.7	5.4	5.6	5.7	5.4
Histidine	2.6	2.9	2.9	3.3	2.8
Isoleucine	4.2	3.9	3.9	4.2	4.3
Leucine	7.1	6.2	6.4	6.5	7.1
Lysine	6.3	5.5	6.5	6.0	4.6
Methionine	1.1	1.2	1.1	1.2	1.3
Phenylalanine	3.8	3.5	3.5	3.3	3.7
Proline	6.7	5.9	7.0	6.6	6.0
Serine	4.7	4.4	4.5	4.4	4.3
Threonine	4.7	4.5	4.7	4.6	4.5
Tyrosine	2.8	3.0	2.7	2.8	3.0
Valine	5.1	5.0	4.9	5.1	5.1
Available lysine	4.2	4.1	4.4	4.4	2.6

protein was 30 %, as opposed to 50—60 % in the other RSM when measured in sacco for 18 h in the rumen (Näsi 1984). The heat treatment was evidently rather strong, since the degradability of the other RSM protein was already low after the normal meal processing. The content of sulphur amino acids in the RSM's was rather low in the present study, compared for example, with the results of Bell (1984).

The digestibility coefficients of the nutrients of the different RSM's calculated by the difference method are shown in Table 2. There was no significant ($P > 0.05$) difference in the organic matter (61—70 %) or crude protein digestibilities (70—74 %) between HGRSM's and LGRSM's or between *B. campestris* and *B. napus,* but the B. napus meal had lower organic matter digestibility due to its lower fat content, while fat was digested fairly efficiently. According to the literature, HGRSM organic matter has a digestibility of 67—69 and that of LGRSM 70—84 %, and the digestibility of their crude protein is 67—80 and 72—86, respectively (Rundgren 1983). The heat treatment reduced the digestibility of organic matter and crude protein significantly ($P < 0.05$). The heat treatment was evidently rather hard, which decreased the digestibility and availability.

The RSM's from *B. campestris* had higher feed values because of their higher fat content, 0.96—0.87 FU/kg DM vs. 0.74—0.70 of RSM from *B. napus.*

Table 2. Digestibility coefficients of nutrients from different rapeseed meals and their calculated feed values.

	B. campestris				*B. napus*					
	HGRSM Span-Torch		LGRSM Sigga		HGRSM Gulliver		LGRSM Topas		LGRSM Heat treated	
	$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.
Digestibilities										
Dry matter	65.0^{ab}	9.3	65.5^{a}	4.2	57.1^{ab}	6.4	60.9^{ab}	3.8	54.0^{b}	8.4
Ash	35.4^{a}	17.3	23.9^{a}	5.1	25.7^{a}	11.6	36.3^{a}	6.9	26.8^{a}	7.1
Organic matter	68.4^{ab}	8.6	69.8^{a}	3.9	60.7^{ab}	5.2	63.9^{ab}	3.8	57.7^{b}	7.1
Crude protein	73.7^{a}	5.4	70.9^{a}	3.1	70.1^{a}	5.3	73.4^{a}	4.5	68.7^{a}	6.9
Ether extract	56.7^{ab}	17.6	75.1^{a}	9.6	neg		5.4^{b}	42.4	49.6^{ab}	16.9
Crude fibre	51.7^{abde}	17.3	66.2^{ad}	13.2	40.5^{abde}	15.7	34.8^{bde}	10.4	25.0^{be}	15.5
Nitrogen free extract	72.7^{a}	10.8	67.7^{a}	8.8	66.8^{a}	9.1	67.2^{a}	9.4	59.3^{a}	5.8
Feed values										
FU/kg DM	0.870		0.958		0.724		0.741		0.698	
kg/FU	1.30		1.17		1.55		1.52		1.66	
DCP % in DM	25.9		24.1		27.8		31.6		28.0	
g DCP/FU	298		252		384		427		413	
MJ, ME/kg DM (Just)	12.87		14.01		11.06		11.48		10.80	
MJ, NE/kg DM »	7.77		8.63		6.42		6.73		6.22	
FU, NE/kg DM »	1.01		1.12		0.83		0.87		0.81	
MJ, ME/kg DM (Axelsson)	11.97		12.92		10.32		10.70		10.03	

Means with different letters were significantly different (a – c $P<0.05$, d – f $P<0.01$)

Table 3. Nitrogen balance and biological value of diets including rapeseed meals from different cultivars and daily gain of pigs.

	B. campestris				*B. napus*					
	HGRSM Span-Torch		LGRSM Sigga		HGRSM Gulliver		LGRSM Topas		LGRSM Heat treated	
	$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.
N intake, g/d	42.4^{a}	11.1	41.9^{a}	10.9	42.3^{a}	11.0	41.8^{a}	10.8	42.5^{a}	11.0
N excreted in faeces, g/d	10.9^{ab}	2.6	11.4^{ab}	2.5	11.6^{ab}	2.5	10.7^{b}	2.1	11.9^{a}	2.1
N absorbed, g/d	31.5^{a}	8.7	30.6^{a}	8.5	30.7^{a}	8.7	31.1^{a}	8.8	30.7^{a}	9.1
N excreted in urine, g/d	11.6^{b}	3.4	11.8^{b}	3.8	11.6^{b}	4.0	12.2^{ab}	4.4	13.7^{a}	4.9
N retained, g/d	20.0^{d}	5.4	18.8^{d}	4.7	19.1^{d}	4.8	18.8^{d}	4.6	16.9^{e}	4.3
— % of intake	46.9^{d}	1.2	45.0^{d}	0.8	45.2^{d}	2.7	45.2^{d}	2.1	39.8^{e}	1.9
— % of absorption	63.4^{d}	2.0	61.9^{d}	2.1	62.6^{d}	3.0	61.1^{d}	3.2	55.8^{e}	2.9
N retained, g/kg $W^{0.75}$/d	1.10^{ad}	0.06	1.01^{bde}	0.08	1.05^{abd}	0.10	1.03^{bde}	0.09	0.93^{ce}	0.07
Urea excreted, g/d	19.7^{be}	6.4	19.7^{be}	6.8	18.4^{be}	7.3	20.1^{bde}	8.2	24.9^{ad}	8.9
Urea excreted, g/kg $W^{0.75}$/d	1.08^{e}	0.18	1.07^{e}	0.13	0.99^{f}	0.21	1.08^{e}	0.24	1.34^{d}	0.23
Creatinine excreted, g/d	1.71^{a}	0.51	1.73^{a}	0.71	1.67^{a}	0.56	1.66^{a}	0.53	1.59^{a}	0.48
Biological value	71.2^{d}	2.2	70.1^{d}	2.3	70.7^{d}	3.1	69.3^{d}	3.3	64.5^{e}	3.4
Daily gain, g/d	687^{a}	84	656^{a}	149	693^{a}	147	604^{a}	151	645^{a}	213

Means with different letters were statistically significant (a – c $P<0.05$; d – f $P<0.01$)

Table 3. presents data on the nitrogen balance and protein utilization. The differences between HG and LG rape types were small and also those between the two *Brassica* species ($P > 0.05$). Heat treatment reduced nitrogen retention and protein utilization ($P < 0.01$). N retention calculated as g/kg $W^{0.75}$ was lower in RSM from Sigga and Topas than

Table 4. Growth rate, feed utilization and carcass quality of pigs on diets in which soybean meal was replaced with different types of rapeseed meal.

Diets	*B. campestris*		*B. napus*		
	HGRSM Span	LGRSM Sigga	HGRSM Gulliver	LGRSM Topas	Control SBM
Initial weight, kg	25.0	25.0	25.0	24.8	25.0
Final weight, kg (corr.)	96.0	96.8	96.6	96.4	97.2
Loss at slaughter, %	28.4	28.3	29.2	28.5	27.4
Daily weight gain, g	771[ab]	796[b]	747[a]	777[ab]	787[b]
FU/pig/d	2.13	2.19	2.12	2.17	2.16
FU/kg gain	2.78	2.75	2.85	2.81	2.75
Kg DM/kg gain	2.57[ab]	2.54[ab]	2.65[a]	2.59[ab]	2.44[b]
Side fat, mm	16.8	16.8	16.7	17.0	17.9
Eye, muscle area, cm^2	38.0	38.7	37.5	37.3	39.3
Colour of lean (points 1—5)	2.4	2.4	2.5	2.5	2.3
Meat in valuable cuts, %	80.6	80.8	80.7	80.6	80.9
Thyroid gland, g	8.8[ab]	8.4[ab]	12.4[a]	9.4[ab]	7.9[b]
Thyroid gland, rel.	(111)	(106)	(157)	(119)	(100)

Means with different letters were significantly different (a – b $P<0.05$)

in RSM from Span-Torch ($P < 0.05$), and heat-treated RSM had a lower value than all the other RSM's ($P < 0.05, 0.01$). The urea excretion, which gives an indication of the amino acid balance in the diet, accorded with the nitrogen retention results; heat treatment of RSM increased urea excretion ($P < 0.01$). The biological values of the various RSM diets were quite close to each other (69—71), but in the diet supplemented with heat-treated RSM this value was significantly reduced ($P < 0.01$). The daily gains recorded after each 12-day balance trial were 600—690 g and differences between the treatments were small ($P > 0.05$).

In the growth trial palatability problems occurred in the groups receiving RSM derived from Gulliver and slight problems in the groups given Span-Torch meal, so that the daily allowances had to be temporarily reduced. This was partly reason for the lower performance of the HGRSM Gulliver group ($P < 0.05$). There were no differences in daily gain between the other RSM groups and the control group receiving SBM. The group receiving LGRSM Sigga performed fairly well; the daily gain was 796 g, as against the control value of 787 g, and the feed conversion efficiency was the same for the two groups, 2.75 FU/kg gain.

The carcass quality was similar in all the groups ($P > 0.05$). The weight of the thyroid gland was elevated in pigs receiving RSM compared to the control value. HGRSM Gulliver gave an increase of 57 %, while in the others it was 6 to 19 % ($P < 0.05$). These results are in accordance with the progoitrin content of the RSM's.

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SELOSTUS

Runsaasti ja vähän glukosinolaatteja sisältävät rypsi- ja rapsirouheet lihasikojen valkuaisenlähteenä

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05840 Hyvinkää

Sulavuus- ja tasekokeessa sekä kasvatuskokeessa tutkittiin kahden rypsirouheen *Brassica campestris* ja kolmen rapsirouheen *B. napus* arvoa lihasikojen valkuaislähteenä. Rouheista oli kaksi runsaasti glukosinolaatteja sisältäviä, lajikkeet Span-Torch (0-rypsi) ja Gulliver (0-rapsi) ja kaksi vähän glukosinolaatteja sisältäviä Sigga (00-rypsi) ja Topas (00-rapsi) sekä yksi lämpökäsitelty rapsirouhe. 00-rypsi Sigga oli keltasiemeninen ohutkuorinen tyyppi, jonka happodetergentti kuidun pitoisuus oli 3/4 osaa muiden rouheiden arvosta. Sulavuus- ja tasekokeessa (5 × 5 latinalainen neliö) rypsi/rapsirouhe oli yksinomaisena valkuaislisänä, 20.2—25.0 % dieetistä. 0-rypsin ja 00-rypsin tai -rapsien välillä ei ollut merkitseviä eroja eri ravintoaineiden sulavuuksien välillä raakakuitua ja -rasvaa lukuunottamatta. Eri rouheiden koostumus oli kuitenkin erilainen mm. rypsirouheissa oli rasvaa n. 10 % kun rapsirouheisiin oli jätetty vain 3 %. Lämpökäsitelty rapsirouhe oli sulavuudeltaan merkitsevästi muita rouheita huonompaa. Rypsirouheiden ry-arvo oli 0.87—0.96 ja rapsirouheiden 0.70—0.74 kg/ry eron johtuessa pääasiassa erilaisesta rasvapitoisuudesta.

Kasvatuskokeessa rypsi/rapsirouheen osuus dieetissä oli 14—15 % ja vertailuseoksessa oli soijarouhetta. Kaikissa koeryhmissä oli 28 eläintä, jotka ruokittiin yhdellä seoksella (135 g srv/ry) koko kasvatuskauden, 25—95. 00-rapsia saaneilla eläimillä esiintyi jonkin verran syömättömyyttä. Lisäkasvu oli merkitsevästi tällä ryhmällä alempi kuin muilla. Rehun hyväksikäytössä (ry/kg lisäkasvua) ei ollut ryhmien välillä tilastollisesti merkitseviä eroja, ei myöskään teuraslaadussa. Kilpirauhasen paino oli kaikilla rypsi/rapsirouhetta saaneilla eläimillä suurempi kuin soijaryhmän eläimillä.