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UTILIZATION OF GROUND SEED OR MEAL FROM LOW ERUCIC ACID RAPE (*BRASSICA CAMPESTRIS* cv. SPAN) IN DIETS FOR GROWING-FINISHING PIGS

A. G. CASTELL¹ and T. M. MALLARD²

¹Agriculture Canada Research Station, P.O. Box 1240, Melfort, Saskatchewan S0E 1A0 and

²National Research Council — Prairie Regional Laboratory, University Campus, Saskatoon, Saskatchewan S7N 0W9.

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Sixty-four pigs, fed ad libitum from 24 to 91 kg liveweight, were used to compare the effects upon live performance, carcass measurements and backfat composition of including rapeseed meal, derived from *B. campestris* (cv. Span) or *B. napus* (cv. Target), or ground Span rapeseed as 10% of diets based on barley with meatmeal or soybean meal as the source of supplementary protein. A further 32 pigs were similarly fed on barley/meatmeal diets containing 0, 4, 8 or 12% of the ground Span rapeseed. Pigs receiving diets containing Span or Target rapeseed meals grew 5 and 15%, respectively, slower than those fed the control diets (0.75 kg/day). The feed:gain ratio was improved with the Span diets (3.77 vs. 3.87) but not with the Target diets (3.97). Estimates of carcass quality also suggested that the meal from Span was superior. Backfat composition was similar on all rapeseed meal diets. Increasing the level of dietary rapeseed tended to reduce the growth rate by up to 11%, but improved the feed:gain ratio up to 8%, and the carcass quality. At levels exceeding 4% there was a marked increase in the degree of unsaturation of the backfat, reflecting increased proportions of linoleic and linolenic acids.

On a comparé sur 64 porcs d'un poids vif de 24 à 91 kg, nourris ad libitum, les effets sur la croissance, les mensurations de la carcasse et la composition du lard dorsal, de l'incorporation de tourteau de colza, dérivés de *B. campestris* (cv. Span), de *B. napus* (cv. Target) ou de colza Span broyé, en proportion de 10% dans des rations d'orge et complétementées de protéine de farine de viande ou de tourteau de soja. Trente-deux autres porcs ont reçu une ration d'orge et de farine de viande contenant 0, 4, 8 et 12% de colza Span broyé. Les taux de croissance des porcs ayant reçu la ration contenant du tourteau de colza Span ou Target ont été, respectivement, de 5 et 15% plus lents que ceux des porcs recevant les rations témoins (0.75 kg/jour). Par ailleurs, l'indice de consommation s'est amélioré avec les rations de Span (3.77 contre 3.87), mais pas avec les rations de Target (3.97). Du point de vue de la qualité de la carcasse, il semble aussi que le tourteau de colza Span soit supérieur. La composition du lard dorsal était identique pour toutes les rations avec tourteau de colza. L'évaluation de la quantité de colza a eu tendance à provoquer une baisse du taux de croissance pouvant aller jusqu'à 11%, mais en même temps une hausse de l'indice de consommation atteignant 8%, et une amélioration de la qualité de la carcasse. Des teneurs en colza de plus 4% ont amené une augmentation marquée de la proportion d'acides gras non saturés linoléiques et linoléiques dans le lard dorsal.

Growth of the Canadian rapeseed industry has benefitted from improvements in methods of processing the seed into oil (RO) and meal (RSM) and from the development of improved cultivars of *Brassica campestris* and *B. napus*. In general, the former variety

Can. J. Anim. Sci. 54: 443-454 (Sept. 1974)

is relatively earlier maturing, but lower yielding, than the latter.

The composition of RO is characterized by a high content of unsaturated fatty acids, although the levels of erucic acid (C 22:1) have been reduced to below 5% in the newer cultivars of low erucic acid rapeseed

(LEAR) varieties. (Throughout the report (Cx:y) represents a fatty acid with x carbon atoms and y double bonds in the molecule.) Canadian RSM contains approximately 36% crude protein, 2% ether extract and 12% crude fiber. It may also contain low levels of goitrogenic compounds, specifically isothiocyanates and oxazolidinethiones, which are derived from hydrolysis of glucosinolates present in the seed. Although the glucosinolate content can vary with the conditions under which the crop was grown, there is usually a lower level of oxazolidinethiones in *B. campestris* (0.2–0.3%, oil-free basis) compared with *B. napus* (0.5–1.0%), whereas the levels of isothiocyanates tend to be similar (0.3–0.7%) in both varieties (Rapeseed Association of Canada 1972).

Many of the published studies that evaluated RSM as a component of swine diets compared meal of unspecified origin with soybean meal (SBM). However, commercially available RSM may currently be more competitive with alternative sources of supplementary protein in view of subsequent changes in processing methods and more widespread production of the LEAR cultivars.

In view of the increasing importance of *B. campestris* cv. Span, which represented an estimated 60% of the rapeseed acreage seeded in the Prairie Provinces in 1973, experiments were conducted to compare unprocessed Span rapeseed (SRS) and Span rapeseed meal (SRSM) with alternative sources of supplementary protein used in diets for growing-finishing pigs.

MATERIALS AND METHODS

The Span rapeseed, obtained from a local source, had the following composition: dry matter 90.3%; oil (extraction by diethyl ether, B.P. 35°) 37.4%; crude protein (N \times 6.25) 20.8%; isothiocyanates 3.3 mg/g and oxazolidinethiones 2.7 mg/g, oil-free basis. Prior to inclusion in a diet, the seed was ground through a 0.32-cm screen. The two types of RSM, namely SRSM and *B. napus* cv. Target (TRSM), were obtained from the same plant (Agra Industries Ltd., Nipawin, Saskatchewan), which uses the pre-press solvent extraction system for removal of RO.

Diets (Table 1) were formulated to contain 16% protein and levels of minerals and vitamins recommended by the National Academy

of Sciences-National Research Council (1968). Inclusion of ground rapeseed or RSM in each of the two basal diets, which contained meal (MM) or SBM, involved removal of a portion of the grain and supplementary protein source so that dietary protein levels remained constant.

In experiment I (January–May 1972), 64 Yorkshire pigs, averaging 23.7 kg and 82 days old, were separated on the basis of gender, litter and liveweight into 16 groups. The two barrows and two gilts in each group were housed in a concrete-floored pen (1.8 \times 3.7 m), bedded with straw and equipped with a self-feeder and self-waterer. The eight diets, representing each basal diet with 0 or 10% SRS, SRSM or TRSM, were randomly assigned to the eight pens in each replicate.

In experiment II (January–April 1972), 32 Yorkshire pigs, averaging 29.2 kg and 87 days old, were similarly separated into eight groups, each containing three barrows and one gilt. Housing was comparable to that used in experiment I except that the pen size (2.9 \times 4.0 m) was larger. The four diets, consisting of the MM basal with 0, 4, 8 or 12% SRS, were each assigned to two groups at random.

Each diet was provided as a dry mash, available ad libitum over the entire experimental period. Individual liveweights and pen feed consumption were recorded weekly. Pigs were shipped to a local packing plant on the weigh-day when their liveweight exceeded 88.5 kg, although a lower limit of 84.0 kg was set for the last pig remaining in a pen. Canadian grade index and record of performance (ROP) measurements (Canada Department of Agriculture 1967) were recorded for each carcass. The ROP yield, which is an estimate of the percentage yield of wholesale cuts, was calculated from the formula:

$$Y = 51.68 - 1.273 \text{ TBF} + 0.161 \text{ LEA} + 48.5 \text{ HW/SW} + 0.827 \text{ HLA/HW}$$

where *TBF* = The sum of three backfat depths (shoulder, midback and loin), in cm

LEA = Loin eye area, in cm²

HW = Ham weight, in kg

SW = Side weight, in kg

HLA = Area of lean in the ham face, in cm².

For barrow carcasses, ROP yield = $Y + 1.1$.

For gilt carcasses, ROP yield = $Y - 1.1$.

In addition, a section of the backfat, approximately 1 \times 3 cm, over the longissimus muscle at the seventh vertebra from the lumbar region, was removed and stored at 0 C in a sealed container.

Table 1. Composition of diets fed in experiments I and II

Experiment no.:	I						II					
	Meat meal			Soybean meal			Meat meal			Meat meal		
	SRS	SRSM	TRSM	—	SRS	SRSM	TRSM	0% SRS	4% SRS	8% SRS	12% SRS	
<i>Ingredients (%)</i>												
Ground barley	89.5	81.3	84.4	84.7	87.3	79.7	83.7	84.0	89.5	86.3	83.1	79.9
Meat meal (50% CP)	9.3	7.2	3.4	3.1					9.3	8.4	7.5	6.6
Ground rapeseed		10.0				10.0				4.0	8.0	12.0
Rapeseed meal			10.0	10.0			10.0					
Soybean meal (44% CP)					10.0	7.6	3.6	3.3				
Cyphos (18.5% Ca, 20.5% P)	0.5	0.6	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.6
Limestone		0.2	0.5	0.5	1.0	1.0	1.0	1.0		0.1	0.2	0.2
Iodized salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Mineral/vitamin mix‡	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
<i>Chemical analyses (as fed)</i>												
Dry matter (%)	90.0	90.0	90.5	90.0	92.0	92.0	91.2	90.6	87.0	88.4	90.5	90.0
Crude protein (%)	16.1	16.4	16.9	16.2	16.2	16.0	16.5	16.7	16.2	16.3	16.0	16.2
Ether extract (%)	3.2	4.8	3.0	2.2	1.7	5.4	1.8	1.8	3.4	5.0	6.4	7.0
Crude fiber (%)	6.7	7.2	6.7	6.7	7.2	8.5	7.4	7.1	6.1	6.2	7.4	7.9
Gross energy (kcal/g)	3.98	4.04	3.93	4.01	3.95	3.98	3.92	3.93	3.95	3.92	4.08	4.23
Digestible energy§ (kcal/g)	3.08	3.30	3.04	3.04	3.08	3.30	3.04	3.04	3.08	3.17	3.26	3.35

†SRS, Span rapeseed; SRSM, Span rapeseed meal; TRSM, Target rapeseed meal.
 ‡Supplies per kg diet = copper 17 mg, iron 89 mg, manganese 21 mg, zinc 70 mg, vitamin A 1323 IU, calcium pantothenate 11 mg, niacin 17.6 mg, riboflavin 3.3 mg, vitamin B₁₂ 11.7 mcg, vitamin D 132 IU and vitamin E 1.3 IU.
 §Calculated, assuming the following values: barley, 3.128; meat meal, 3.010; rapeseed meal, 2.942; soybean meal, 3.476 (NAS-NRC, 1968); and rapeseed, 5.400 kcal/g (Bowland 1971).

Chemical Analysis

The crude fiber, crude protein (%N \times 6.25), ether extract and gross energy contents of representative samples of each diet were determined by standard methods (Association of Official Agricultural Chemists (AOAC) 1960).

Each backfat sample was split vertically and a thin cross-section (consisting of skin, outer and inner fat layers) removed from the freshly cut surface. After discarding the skin layer, the section was divided along the line of connective tissue into the outer and inner fat. Each portion was directly methylated, using a mixture of acetyl chloride, benzene and methanol (1:1:8 v/v). Following neutralization of the excess HCl with K_2CO_3 , the esterified fatty acids were extracted with petroleum ether (Skelly F, B.P. 36°). Following removal of the solvent under vacuum, carbon disulfide was added prior to injection of a 1- μ liter sample into the gas chromatograph (Hewlett Packard #5750, equipped with hydrogen flame detector). The following conditions applied:

Column — 0.32 cm \times 244 cm, stainless steel, thin wall

Packing — 60/80 mesh Chrom W, acid-washed

Coating — 4% 1,3 propanediol succinate; 1% ethylene glycol succinate

Temperatures — injection 250 C, column 190 C, detector 250 C

Flow rates — carrier gas (helium) 60 ml/min, hydrogen 40 ml/min; air 400 ml/min.

Peak areas were calculated automatically with an Infotronics Integrator #204.

Values for individual fatty acids represented the weight percent of the total fatty acids (TFA) appearing on the chromatograph. The seven fatty acids (14:0, 16:0, 16:1, 18:0, 18:1, 18:2 and 18:3) studied represented approximately 97% of the TFA.

Feed samples, placed in Swedish steel tubes (Troeng 1955), were extracted with petroleum ether for 45 min and the distribution of the fatty acids in these extracts was determined by the above method of esterification and analysis. The concentration of individual fatty acids in each diet (Table 2) was based on the assumption that TFA represented 90% of the ether extract.

Statistical Analysis

For experiment I, the analyses of variance were based on a randomized block design involving two replicates, two genders (barrow and gilt), two sources of supplementary protein (MM and SBM) and four types of supplement (0 and

10% SRS; 10% SRSM or 10% TRSM). In experiment II, the data were analyzed on the basis of two replicates and four supplements (0, 4, 8 and 12% SRS), with linear contrasts used to compare the results derived from the three barrows and one gilt in each group. As barrows and gilts were fed together in both experiments the effects of gender on feed data were not available for analysis.

Analyses were conducted by the Agriculture Canada Statistical Research and Data Processing Services, Ottawa, Ontario. Missing values were estimated by minimizing the sum of squares of the 'residual' term in the analysis of variance. Within variable means were compared using the multiple range test (Duncan 1955).

Differences were regarded as significant at $P < 0.05$ and highly significant at $P < 0.01$.

RESULTS

Experiment I

Midway through the feeding period, one of the gilts receiving the SBM basal diet developed leg weakness, necessitating its removal from the experiment and substitution of missing plot values.

Significant interactions between the type of rapeseed supplement and supplementary protein source were observed, particularly when the backfat composition data were analyzed. Consequently the mean values for each of the eight diets (Table 3) as well as the treatment effects (Table 4) are presented.

LIVE PERFORMANCE. For the overall period, gilts had a 5.5% slower growth rate ($P < 0.05$) than barrows; however, the type of supplementary protein had no apparent effect upon average daily gains (ADG). Although inclusion of the rapeseed supplements depressed the growth rate, the performance on basal and SRSM diets was not significantly different (0.75 and 0.71 kg/day, respectively) whereas the reduction in ADG represented 8% for the SRS diets and 15% for the TRSM diets.

Feed:gain ratios were not significantly influenced by either the type of basal protein or rapeseed supplement; however, the higher energy diets, containing 10% rapeseed, were most efficiently used. Comparison of the performance of pigs receiving the RSM diets suggested that SRSM was superior to TRSM when soybean meal was used as the basal protein.

Table 2. Calculated levels of fatty acids in the diets and distribution of fatty acids in oil from Span rapeseed

Experiment no.:	I										II			
	Basal protein:		Meat meal		Soybean meal		Meat meal		Soybean meal		Meat meal		Span rapeseed‡	
	Supplement†	—	SRS	SRSM	TRSM	—	SRS	SRSM	TRSM	0% SRS	4% SRS	8% SRS		12% SRS
Ether extract	3.17	4.84	3.01	2.19	1.82	1.73	5.44	1.85	1.82	3.38	4.99	6.37	6.99	37.4
<i>Fatty acid, % of diet§</i>														
Myristic 14:0	0.04	0.03	0.03	0.02	0.02	0.32	0.52	0.32	0.29	0.04	0.05	0.05	0.04	
Palmitic 16:0	0.64	0.61	0.53	0.39	0.39	0.03	0.02	0.01	0.01	0.75	0.81	0.89	0.83	3.5
Palmitoleic 16:1	0.02	0.04	0.04	0.02	0.02	0.03	0.02	0.01	0.01	0.06	0.06	0.06	0.06	0.3
Stearic 18:0	0.26	0.19	0.18	0.10	0.10	0.12	0.03	0.02	0.02	0.28	0.32	0.29	0.27	1.5
Oleic 18:1	0.86	1.82	0.83	0.50	0.50	0.25	2.16	0.33	0.29	0.98	1.71	2.42	2.83	56.9
Linoleic 18:2	0.85	1.24	0.89	0.72	0.72	0.84	1.46	0.81	0.77	0.83	1.22	1.50	1.63	21.7
Linolenic 18:3	0.12	0.29	0.13	0.09	0.09	0.10	0.38	0.09	0.09	0.09	0.22	0.37	0.45	10.1
Eicosenoic 20:1	0.04	0.06	0.04	0.05	0.05	0.02	0.08	0.02	0.05	0.02	0.06	0.07	0.08	0.5
	20:2			0.01									0.01	2.5
	20:3													0.1
Erucic 22:0		0.01			0.01		0.01	0.01	0.01					0.2
Saturated 22:1	0.03	0.05	0.04	0.07	0.07	0.01	0.08	0.01	0.08		0.04	0.06	0.08	2.6
Unsaturated	0.94	0.84	0.74	0.51	0.51	0.32	0.66	0.35	0.32	1.07	1.18	1.23	1.15	
UFA as % TFA//	1.92	3.50	1.97	1.46	1.46	1.25	4.18	1.27	1.29	1.98	3.31	4.48	5.14	
	64.7	78.1	69.7	67.5	67.5	77.7	83.1	76.5	72.0	64.3	71.5	76.2	79.0	89.1

†SRS—Span rapeseed, SRSM—Span rapeseed meal, TRSM—Target rapeseed meal included at 10% of the diets in experiment I.

‡In this column, data for fatty acids represent weight % of total fatty acids in ether extract.

§Assuming total fatty acids represent 90% of ether extract.

//16:1 + 18:1 + 18:2 + 18:3 as percentage of total fatty acids.

CARCASS DATA. Gilt carcasses contained significantly less backfat ($P < 0.05$), larger loin eye areas ($P < 0.01$) and higher percentages of lean in the ham face ($P < 0.01$) than

those of barrows; however, the carcass value indices were not significantly different. Although the differences in loin eye area and percent lean in ham face were not signifi-

Table 3. Average daily gain, feed conversion, carcass measurements and backfat composition of pigs in experiment I

	Basal protein:				Soybean meal (SBM)			
	Meat meal (MM)							
	Supplement†:	-	SRS	SRSM	TRSM	-	SRS	SRSM
No. of pigs:	8	8	8	8	8‡	8	8	8
Initial age (days)	75	84	79	85	84	84	84	81
Initial liveweight (kg)	23.6	23.7	23.8	24.0	23.5	23.6	24.0	23.5
<i>Overall period (24-91 kg)</i>								
Average daily gain (kg)	0.76	0.71	0.69	0.62	0.75	0.67	0.73	0.65
Average daily feed (kg)	2.89	2.49	2.62	2.39	2.97	2.51	2.71	2.64
Feed/kg gain (kg)	3.82	3.52	3.83	3.84	3.92	3.77	3.71	4.09
<i>Carcass data</i>								
Dressing (%)	79.2	78.1	79.0	78.4	77.6	77.4	78.1	78.2
Carcass weight (kg)	72.0	70.8	71.8	71.7	71.9	70.9	72.4	70.3
Average backfat (mm)	31.0	29.1	28.9	30.5	26.7	27.8	28.6	29.6
Loin eye area (cm ²)	31.5	34.8	32.3	33.8	35.5	35.7	32.5	33.8
Lean in ham face (%)	48.2	52.0	50.0	52.6	53.4	55.0	52.0	49.7
Carcass value index	103.6	104.6	105.5	103.7	107.0	105.5	105.9	104.6
ROP yield (%)	70.0	71.8	71.1	71.3	73.5	73.5	71.6	70.9
<i>Backfat composition</i>								
<i>Outer layer, % of total FA</i>								
Myristic 14:0	1.7	1.5	1.6	1.5	1.5	1.3	1.6	1.5
Palmitic 16:0	24.5	23.3	24.1	24.3	24.6	21.0	24.7	24.4
Palmitoleic 16:1	4.9	4.2	4.3	4.1	3.9	3.3	4.2	4.1
Stearic 18:0	9.4	9.0	9.3	9.4	10.5	8.2	10.1	9.9
Oleic 18:1	50.0	50.1	49.1	48.9	46.2	49.1	47.5	48.0
Linoleic 18:2	6.2	7.9	7.4	8.0	9.3	11.8	7.8	8.0
Linolenic 18:3	0.5	1.1	0.8	0.8	0.9	2.2	0.7	0.8
SFA (14:0+16:0+18:0)	35.6	33.8	35.0	35.2	36.7	30.6	36.3	35.7
UFA (16:1+18:1+18:2+18:3)	61.6	63.3	61.6	61.9	60.2	66.4	60.2	61.0
UFA/SFA	1.73	1.88	1.76	1.77	1.65	2.18	1.66	1.71
<i>Inner layer, % of total FA</i>								
14:0	1.6	1.7	1.5	1.6	1.5	1.4	1.4	1.6
16:0	25.6	25.9	25.7	26.8	26.5	22.9	26.1	26.8
16:1	4.5	3.9	3.7	3.8	3.3	2.8	3.4	3.7
18:0	11.1	10.9	11.9	11.4	12.9	10.5	13.1	12.1
18:1	48.7	46.8	48.0	46.5	44.7	46.5	46.1	45.2
18:2	6.1	7.4	6.3	6.8	7.9	10.9	6.8	7.0
18:3	0.4	1.0	0.6	0.7	0.8	2.1	0.5	0.8
SFA (14:0+16:0+18:0)	38.3	38.6	39.1	39.8	40.9	34.8	40.7	40.6
UFA (16:1+18:1+18:2+18:3)	59.8	59.0	58.7	57.7	56.6	62.3	56.8	56.7
UFA/SFA	1.57	1.53	1.50	1.46	1.39	1.80	1.40	1.40
Outer UFA/inner UFA	1.031	1.073	1.050	1.074	1.064	1.066	1.059	1.076

†0 or 10% Span rapeseed (SRS), Span rapeseed meal (SRSM) or Target rapeseed meal (TRSM).

‡One gilt removed prior to completion of experiment; data adjusted by missing plot analysis.

Table 4. Effects of gender of pig, basal protein and rapeseed supplementation on live performance, carcass measurements and backfat composition in experiment I

Factor	Significance‡	Gender (G)				Basal protein (P)				Rapeseed supplement (S)				df					
		Barrow		Gilt		MM		SBM		SE		16†			16		SE		
		32	32†	32	32†	32	32†	32	32†	16†	16	16	16		16	16	16	16	
ADG, 24-56 kg, kg																			
G	S	0.68	0.62**	0.01	0.64	0.66	0.01	0.70	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.02	47
24-91 kg, kg																			
G	S	0.72	0.68*	0.01	0.69	0.70	0.01	0.75	0.69	0.69	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.02	46
F/G, 24-56 kg, kg/kg																			
					3.46	3.34	0.07	3.48	3.27	3.42	3.44	3.44	3.44	3.44	3.44	3.44	3.44	0.10	7
24-91 kg, kg/kg																			
					3.75	3.87	0.07	3.87	3.65	3.77	3.97	3.97	3.97	3.97	3.97	3.97	3.97	0.11	6
Carcass data																			
R	P	78.4	78.1	0.2	78.7	77.8**	0.2	78.4	77.7	78.6	78.3	78.3	78.3	78.3	78.3	78.3	78.3	0.3	46
Dressing (%)																			
G	P	29.9	28.2*	0.5	29.9	28.2*	0.5	28.8	28.5	28.7	30.1	30.1	30.1	30.1	30.1	30.1	30.1	0.6	46
Average backfat (mm)																			
G	P	31.6	35.8**	0.5	33.1	34.4	0.5	33.5	35.2	32.4	33.8	33.8	33.8	33.8	33.8	33.8	33.8	0.7	46
Loin eye area (cm²)																			
G	P	49.1	54.1**	0.8	50.7	52.5	0.8	50.8	53.5	51.0	51.2	51.2	51.2	51.2	51.2	51.2	51.2	1.1	46
Lean in ham face (%)																			
		104.7	105.1	0.4	104.4	105.8*	0.4	105.3	105.1	105.7	104.2	104.2	104.2	104.2	104.2	104.2	104.2	0.5	46
Carcass value index																			
P	P	71.8	71.7	0.4	71.1	72.4*	0.4	71.7	72.7	71.3	71.1	71.1	71.1	71.1	71.1	71.1	71.1	0.5	45
ROP yield (%)																			
Outer backfat composition																			
g	P	1.6	1.5*	0.03	1.6	1.5*	0.03	1.6	1.4	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0.04	46
14:0 (%)																			
g	S	24.2	23.5*	0.2	24.0	23.7	0.2	24.6	22.2	24.4	24.3	24.3	24.3	24.3	24.3	24.3	24.3	0.3	46
16:0 (%)																			
P	S	4.2	4.1	0.07	4.4	3.9**	0.07	4.4	3.7	4.3	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.10	46
Palmitoleic																			
R	P	9.5	9.5	0.1	9.3	9.7**	0.1	10.0	8.6	9.7	9.6	9.6	9.6	9.6	9.6	9.6	9.6	0.2	46
18:0 (%)																			
P	S	48.8	48.5	0.3	49.5	47.7**	0.3	48.1	49.6	48.3	48.5	48.5	48.5	48.5	48.5	48.5	48.5	0.4	46
Oleic																			
r	G	7.8	8.8**	0.2	7.4	9.2**	0.2	7.7	9.9	7.6	8.0	8.0	8.0	8.0	8.0	8.0	8.0	0.3	46
Linoleic																			
r	G	0.9	1.0*	0.03	0.8	1.2**	0.03	0.7	1.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.05	46
18:3 (%)																			
r	G	35.3	34.5	0.3	34.9	34.8	0.3	36.1	32.2	35.7	35.5	35.5	35.5	35.5	35.5	35.5	35.5	0.4	46
SFA (14:0+16:0+18:0) (%)																			
UFA																			
r	G	61.7	62.4	0.3	62.1	62.0	0.3	60.9	64.9	60.9	61.5	61.5	61.5	61.5	61.5	61.5	61.5	0.4	46
(16:1+18:1+18:2+18:3) (%)																			
r	G	1.76	1.82*	0.02	1.79	1.80	0.02	1.69	2.03	1.71	1.74	1.74	1.74	1.74	1.74	1.74	1.74	0.03	46
UFA/SFA																			
Outer UFA/inner UFA	S	1.059	1.064	0.003	1.057	1.066	0.003	1.047	1.069	1.055	1.075	1.075	1.075	1.075	1.075	1.075	1.075	0.005	46

†One pig removed prior to completion of test.
‡R, r, G, g; P, p, S, s indicate replicates, gender, protein or supplement differences significant at $P < 0.01$ (**), $P < 0.05$ (*), and $P < 0.05$ (ns), respectively. In any row, means with the same letter did not differ significantly ($P < 0.05$).

cant, the other carcass measurements indicated that pigs consuming the SBM diets produced significantly leaner carcasses than those fed the MM diets.

Inclusion of a rapeseed supplement as 10% of either basal diet did not result in significant differences in measurements of carcass quality. However, the lower backfat measurements and higher carcass value indices favored the use of SRSM over TRSM. **BACKFAT COMPOSITION.** Fat in the outer layer tended to contain lower proportions of palmitic (16:0) and stearic (18:0) acids with higher percentages of palmitoleic (16:1), oleic (18:1), linoleic (18:2) and linolenic (18:3) acids and consequently was more unsaturated than fat in the inner backfat layer. As treatment effects were generally similar in each layer, most of the results presented will refer to the differences observed in the outer backfat.

Fat from gilt carcasses contained a lower proportion ($P < 0.10$) of saturated fatty acids (SFA) than was found in carcasses from barrows. This was a reflection of the significantly ($P < 0.05$) lower percentages of 14:0 and 16:0 acids and higher concentrations of 18:2 ($P < 0.01$) and 18:3 ($P < 0.05$) acids in the former samples.

Relative proportions of individual fatty acids tended to be quite different when MM or SBM diets were fed, although there was no difference in the degree of unsaturation as measured by the ratio of unsaturated fatty acids (UFA) to SFA. Pigs receiving the MM diets had lower levels of 18:0 ($P < 0.05$), 18:2 ($P < 0.01$) and 18:3 ($P < 0.01$) and higher percentages of 14:0 ($P < 0.05$), 16:1 ($P < 0.01$) and 18:1 ($P < 0.01$) fatty acids. These differences were also apparent when the composition of the backfat from pigs fed the MM and SBM basal diets were compared.

Inclusion of the rapeseed supplements in the basal diets produced significant changes in the backfat composition although these were predominantly a result of using rapeseed rather than RSM. The significant protein \times supplement interactions further revealed that the rapeseed effect on fatty acid distribution was greater when pigs were fed the SBM diets rather than the MM diets. The fat composition in pigs receiving diets

containing either type of RSM was similar to that found when the corresponding basal diet was fed.

Comparison of the relative proportions of UFA in the outer and inner backfat layers revealed unexpected differences, namely a highly significant supplement effect and significant supplement interactions with gender and basal protein. In the former case, pigs fed the SRS or TRSM diets had significantly higher ratios, 1.069 and 1.075, respectively, than those fed the basal (1.047) or SRSM (1.055) diets. The gender \times supplement interaction reflected the slightly higher ratios for gilts on the basal and RSM diets, whereas barrows had the higher value when rapeseed diets were consumed. The protein \times supplement interaction was basically a result of the difference between the basal diets (MM, 1.031; SBM, 1.064).

Experiment II (Table 5)

One barrow, which had received the 8% SRS diet, died during transfer to the packing plant; consequently carcass data for this pig were calculated.

LIVE PERFORMANCE. Barrows had a significantly faster ($P < 0.01$) rate of growth during the growth period prior to 56 kg live-weight, but for the overall period the slightly higher ADG for barrows was not significant.

Increasing the level of SRS in the diet tended to reduce the growth rate and feed:gain ratios although the differences were not significant.

CARCASS DATA. Gilts had significantly lower dressing percentages and less backfat, but larger loin eye areas and percent lean in the ham face than barrows. The carcass value indices, however, were not significantly different.

Composition of the diets did not significantly influence the carcass measurements, although there was a trend towards leaner carcasses as the dietary level of SRS increased to 8%.

BACKFAT COMPOSITION. Significantly higher proportions of 18:2 and 18:3 ($P < 0.01$) fatty acids were found in the fat samples obtained from gilts; however, the degree of unsaturation of the fat was not significantly different.

Table 5. Effects of gender of pig and level of dietary rapeseed on live performance, carcass measurements and backfat composition of pigs in experiment II

Factor	Significance‡	Gender		Supplement								df			
		Barrow		Gilt		0% SRS		4% SRS		8% SRS			12% SRS		SE
		24†	8	8	8	8	8	8	8†	8	8		8		
ADG, 29-56 kg, kg	G	0.75	0.63**	0.74	0.70	0.73	0.71	0.73	0.71	0.73	0.71	0.73	0.03	27	
ADG, 29-91 kg, kg	G	0.77	0.73	0.80	0.77	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.03	27	
F/G, 29-56 kg, kg/kg				3.34	3.38	2.97	3.15	2.97	3.15	2.97	3.15	2.97	0.06	3	
29-91 kg, kg/kg				3.63	3.51	3.47	3.51	3.47	3.51	3.47	3.51	3.47	0.06	3	
Carcass data															
Dressing (%)	g	78.7	77.3*	78.3	78.1	79.2	77.8	79.2	77.8	79.2	77.8	79.2	0.6	26	
Average backfat (mm)	g	32.3	27.8*	33.2	32.0	29.9	29.4	29.9	29.4	29.9	29.4	29.9	0.1	26	
Loin eye area (cm ²)	g	30.3	34.4*	30.0	31.2	32.4	31.9	32.4	31.9	32.4	31.9	32.4	1.3	26	
Lean in ham face (%)	g	48.0	51.7*	46.3	48.6	50.6	50.0	50.6	50.0	50.6	50.0	50.6	1.5	26	
Carcass value index		103.6	105.2	103.0	103.9	105.1	104.1	105.1	104.1	105.1	104.1	105.1	1.0	26	
ROP yield (%)		69.6	70.5	68.2	69.7	70.8	70.7	70.8	70.7	70.8	70.7	70.8	0.7	26	
Outer backfat composition															
Myristic 14:0 (%)		1.6	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.14	26	
Palmitic 16:0 (%)	S	23.9	23.1	25.4a	24.5a	22.9b	22.0b	22.9b	22.0b	22.9b	22.0b	22.9b	0.5	26	
Palmitoleic 16:1 (%)		3.9	4.0	4.2	4.0	3.9	3.5	3.9	3.5	3.9	3.5	3.9	0.22	26	
Stearic 18:0 (%)	S	9.5	9.0	10.4a	9.7a	8.8b	8.5b	8.8b	8.5b	8.8b	8.5b	8.8b	0.3	26	
Oleic 18:1 (%)	R	49.7	49.6	49.5	49.4	50.3	49.5	50.3	49.5	50.3	49.5	50.3	0.6	26	
Linoleic 18:2 (%)	g	8.1	9.1*	6.6a	7.9b	8.6b	10.3c	8.6b	10.3c	8.6b	10.3c	8.6b	0.3	26	
Linolenic 18:3 (%)	G	1.0	1.3**	0.4a	0.9b	1.4c	1.8d	0.9b	1.4c	1.4c	1.8d	0.9b	0.07	26	
SFA (14:0+16:0+18:0) %	S	35.0	33.6	37.5a	35.7a	33.3b	32.2b	33.3b	32.2b	33.3b	32.2b	33.3b	0.7	26	
UFA (16:1+18:1+18:2+18:3) %	r	62.7	64.0	60.7a	62.1a	64.1b	65.2b	64.1b	65.2b	64.1b	65.2b	64.1b	0.6	26	
UFA/SFA	S	1.80	1.93	1.62a	1.74a	1.93b	2.05b	1.93b	2.05b	1.93b	2.05b	1.93b	0.05	26	
Outer UFA/inner UFA		1.046	1.054	1.053	1.063	1.044	1.031	1.044	1.031	1.044	1.031	1.044	0.010	26	

a,b In any row, means with the same letter did not differ significantly ($P < 0.05$).

†Carcass and fat data missing for one pig.

‡R, G, S, s indicate replicate, gender or supplement differences significant at $P < 0.01$ (**), $P < 0.05$ (*), respectively.

Diet had a marked effect upon backfat composition, notably a highly significant reduction in the percentages of 16:0 and 18:0 acids and corresponding increases in the proportions of 18:2 and 18:3 acids as the dietary level of SRS increased. The effect was apparently significant when the level of rapeseed exceeded 4% of the diet.

Comparison of the relative percentages of UFA in the outer and inner backfat did not reveal significant treatment differences although the ratio tended to decline as the amount of rapeseed exceeded 4% of the diet.

DISCUSSION

Rapeseed Meal Diets

Reviews by Bowland (1965) and Bowland and Bell (1972) suggest that the general effect of using RSM in diets for growing-finishing pigs is a depression in feed intake and growth rate when the level reaches 10% of the diet. The poorer live performance is often offset by an improvement in carcass quality and consequently there may be negligible changes in the economic evaluation, even when RSM represents the only protein supplement in a balanced diet. Although our earlier studies (unpublished) in comparing Target RSM with SBM reached similar conclusions, there is an obvious advantage in maximizing the use of locally produced feedstuffs which can replace ingredients which may become relatively expensive or unavailable.

The better performance obtained with Span RSM compared with Target RSM may have been related to the relative contents of glucosinolates in the RSM. Target is a cultivar of *B. napus*, a variety which generally contains higher levels of glucosinolates than *B. campestris* (Rapeseed Association of Canada 1972). Bell (1965) has identified these compounds as being potential growth depressants for swine. Because group feeding was practised, it was not possible to statistically separate the relative effects of the RSM types on feed intake or efficiency of feed conversion. It appeared, however, that differences attributable to the origin of the RSM were more evident when SBM was the alternative source of supplementary protein.

It is not always possible to separate carcass differences which reflect direct effects attributable to the diet, e.g. content of available nutrients, from indirect effects which represent differences in growth rate or gender of the pig. This is illustrated by comparing the results obtained with the basal and TRSM diets. Live performance on the MM and SBM basal diets was similar although pigs on the latter diet had leaner carcasses. Inclusion of 10% TRSM depressed the feed intake and growth rate of pigs receiving either basal diet; however, there was an apparent increase in relative carcass fatness when the SBM diet was supplemented. The apparent conflict in results could be explained by assuming that the meatmeal was a poorer source of essential amino acids than the soybean meal. The assumption has support from the results of Puchal et al. (1962), McNichol (1966) and Boyne et al. (1967). On the basis of the carcass data, Span RSM would appear to be preferable to Target RSM.

Addition of RSM did not change the relative proportions of individual fatty acids in either backfat layer. Minor changes in backfat composition for pigs receiving the basal or RSM diets were similar to those reported by Elliot and Bowland (1970). The type of RSM, however, apparently influenced the relative percentages of UFA in each backfat layer. It was not possible to determine whether this represented an actual difference in the amounts of fatty acids present in each layer or an effect upon distribution between the layers. Although the outer layer of backfat is invariably more unsaturated than the inner layer, the relative depths of each layer, and presumably the relative amounts of fat within each layer, may be changed by factors which influence the metabolism and synthesis of body fat. Changes in fat composition within a layer may not directly reflect the change in absolute amounts of individual fatty acids in the depot fat. The interpretation of changes in fat composition is also complicated by the fact that the 16:0, 16:1, 18:0 and 18:1 fatty acids are predominantly derived via endogenous synthesis, whereas the proportions of 18:2 and 18:3 acids tend to reflect the levels present

in the diet (Leat et al. 1964; Koch et al. 1968).

Rapeseed Diets

Inclusion of SRS in the basal diets, fed in either experiment, tended to depress the growth rate and feed intake. Bowland (1971) reported that feed intake was reduced by approximately 2% for each 1% of dietary rapeseed added. Current results tend to support this at a low (4%) level of feeding, but not at higher levels where the reductions represented approximately 1.5% per 1% dietary rapeseed at 8–10% added SRS and about 1.0% per 1% RS at the 12% dietary level.

The improvement in feed conversion when rapeseed was fed was probably associated with the increase in digestible energy content of the diet. The results from both experiments suggested that the use of 8–10% rapeseed in the diet improved the nutrient balance as feed:gain ratios and carcass quality were enhanced. The energy:protein levels in these diets, i.e. approximately 3,300 kcal digestible energy per kg and 16% crude protein, compare favorably with current recommendations.

Addition of SRS, at levels exceeding 4% of the diet, increased the degree of unsaturation of the backfat. In experiment I, changes in the proportions of individual fatty acids when rapeseed was used were more evident for the SBM-fed pigs. Inclusion of SRS in these diets had a greater effect upon the dietary contribution of fatty acids than addition of SRS to the MM-basal diet. The effect of the composition of dietary fat on distribution of fatty acids within depot fat has been previously noted (Leat et al. 1964; Sink et al. 1964; Koch et al. 1968). In experiment II, there was a progressive increase in the proportions of 18:2 and 18:3 fatty acids in the backfat as the dietary level of these acids increased. It could be suggested that increasing the amount of these fatty acids in pork fat used in human diets might help to maintain low serum cholesterol levels. However, Koch et al. (1968) have questioned this assumption because the triglyceride structure of lard apparently does not adapt itself to reducing serum cholesterol levels (Elson 1964). The beneficial effect of polyunsatu-

rated fats on cholesterol levels may depend upon the positional distribution of fatty acids within the triglyceride molecules. In vegetable oil triglycerides, the saturated fatty acids are mainly located in the external positions, α and α' , whereas in lard they tend to occupy the internal, β , position (Mattson and Volpenheim 1963; Mattson et al. 1964).

CONCLUSION

On the basis of the experimental results, meal from a widely grown *B. campestris* cultivar, Span, was superior to that obtained from Target, a *B. napus* cultivar, when used as 10% of growing-finishing diets for pigs.

Inclusion of up to 12% Span rapeseed in such diets did not adversely affect the overall performance and could represent a simple method of modifying either the energy:protein ratio in the diet or the depot fat composition in the market pig.

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