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The energy and protein value of double-low rape seeds for growing pigs

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ABSTRACT

Groups of 12 growing Landrace pigs with an average body weight of 55 ± 1.5 kg were fed a diet containing from 5 to 30% (Expt. 1) or 0 to 25% (Expt. 2) raw rape seeds. The digestibility of the diet was determined by either the indicator method (Expt. 1) or total collection method (Expt. 2). Metabolizability of energy was also determined in experiment 2. The apparent digestibility of crude protein was not dependent on the proportion of rape seeds in the diet, whereas the digestibility and metabolizability of energy decreased after the rape seed content exceeded 15% (Expt. 2) or 20% (Expt. 1). The mean coefficient of digestibility and metabolizability of energy and apparent digestibility of protein determined by multiple equations when the rape seed content equalled to 15 and 20%, were: 76.1 ± 1.8%, 66.4 ± 2.4% and 75.8 ± 3.5%, respectively. The digestible and metabolizable energy contents and digestible protein content in 1 kg DM of seeds were, respectively: 22.4, 20.2 MJ and 156 g.

KEY WORDS: rape seeds, metabolizable energy, protein digestibility, growing pigs

INTRODUCTION

Increased cultivation of „00" varieties of rape (with glucosinolate contents below 30 μmol/g fat-free DM) presents an opportunity to use raw rape seed (RS) and oil meal on a wider scale in the feeding of monogastric animals. RS from "00" cultivars contains approximately 40% ether extract and 20% protein and is a potential source of dietary energy and protein for pigs.

There have been few studies on the nutritive value of "00" cultivars for pigs. In experiments of Salo (1980) and Bourdon et al. (1990) protein digestibility varied widely, from 68.9 to 83.7%, while the digestibility of energy was 83.7% (Bourdon et al., 1990). Other authors (e.g. Ochetim et al., 1980; Show et al., 1990) reported, that diets with a high RS content (from 15 to 30%) were less digestible to pigs than diets without RS. This suggests that such components of RS as glucosinolates, fibre and fatty acids introduced into the diet in excessive amounts can have a deleterious effect on its nutritive value.

The main objective of the study was to give more information on the nutritive value of low-glucosinolate rape seeds for pigs. The influence of various proportion of RS in the diet on the apparent digestibility of protein and energy and metabolizability of energy was investigated.

MATERIAL AND METHODS

The digestibility and metabolizability of energy and protein digestibility of RS can be determined using the following regression model:

$$Y = b_1 \cdot x_1 + b_2 \cdot x_2 \qquad (1)$$

where:

- Y = intake of digestible energy, metabolizable energy (MJ/d) or digestible protein (g/d);
- x_1 = intake of energy (MJ/d) or protein (g/d) of the tested feed;
- x_2 = intake of energy (MJ/d) or protein (g/d) of the basal feed;
- b_1 = digestibility or metabolizability of energy or protein digestibility of the tested feed;
- b_2 = digestibility or metabolizability of energy or protein digestibility of the basal feed.

Two experiments were carried out, both on twelve growing pigs of the Landrace breed, with an average body weight of 55 kg. In experiment 1, the pigs were fed on a barley diet containing 5, 10, 15, 20, 25 or 30% RS (Table 2). The energy and protein digestibilities of these diets were determined by the indicator method (0.5% Cr_2O_3) with a four-day period of faeces collection preceded by a 14-day preliminary period.

In experiment 2, the animals were given a diet containing rape seed and rapeseed oil meal produced from the same batch of RS as that used in experiment 1. The proportion of rapeseed oil meal was constant (18%). The proportion of RS in the diet increased from 0 to 5, 10, 15, 20 or 25% while the amount of barley decreased (Table 3). The diets contained not less than 16% crude protein and 0.83% lysine, which corresponds to the minimum level of these components in standard feeds for fatteners. The digestibility of energy and protein and metabolizability of energy of the diets were determined by classical method. The 14 days preliminary period preceded 4 days of faeces and urine collection.

The rape seeds were mixed at a ratio 1 : 1 with barley and crushed. The classical methods were used for the chemical analysis of feeds, complete diets, faeces and urine. NDF and ADF were determined by the Van Soest method (1967, 1973) in a Tecator "Fibertec-System M" apparatus. The amino acid composition of the seeds and rapeseed oil meal was determined following protein hydrolysis (Buraczewska et al., 1984) using a Beckman Unichrom analyzer and the total glucosinolate content by a modified Youngs-Wetter method (Byczyńska, 1971). The gross energy content of feeds, faeces and urine was determined by combustion of samples in a bomb calorimeter. Energy loss in gasses was not included in the calculation of metabolizable energy.

TABLE 1

Composition of rape seed and rapeseed oil meal

	Rape seed		Rapeseed oil meal
	Data from literature[1]	Present data	
Chemical composition, %			
Dry matter	95.1 ± 1.7	95.1	89.4
In dry matter:			
Ash	4.9 ± 0.4	4.2	7.7
Crude protein	22.5 ± 0.4	20.6	37.4
Ether extrakt	43.4 ± 1.7	45.3	3.7
Crude fibre	9.2 ± 2.0	7.3	13.6
NDF	21.0	30.1	34.8
ADF	14.0	28.2	30.9
N-free extractives	20.0	22.6	37.6
Gross energy, MJ/kg	27.4 ± 0.2	29.4	19.5
Total glucosinolate μmol/g fat-free dry matter	26 – 36	22.8	5.5
Amino acids, g/ 16 g N			
Lys	5.45[2]	6.55	5.48
Met	1.87	2.17	2.07
Cys	1.56	2.77	2.51
Thr	4.63	4.79	4.52
Tyr	1.42	1.41	1.42
Val	4.42	6.24	5.72
Ileu	3.24	4.70	4.50
Leu	6.81	7.65	7.30
His	2.64	3.10	2.60
Arg	6.62	7.25	6.20
Phe	3.84	4.50	4.35

[1] Average — from Bourdon et al. (1990), rolling + moderate heating; Ochetim et al. (1980), micronisation rolling and Salo (1980), rape seed-low glucosinolate;

[2] amino acid — from Ochetim et al. (1980).

RESULTS AND DISCUSSION

The crude protein, fat and crude fibre contents in the seeds were similar (Table 1) to those of the low-glucosinolate RS used by Salo (1980), Ochetim et al. (1980) and Bourdon et al. (1990) in experiments with pigs. The levels of essential amino acids, especially lysine (6.55 vs. 5.45 g/16 g N), were higher than in the seeds used in the study of Ochetim et al. (1980). With a similar crude protein content (in fat-free DM), the protein in rapeseed oil meal contained about 17% less lysine than seed protein (5.48 vs. 6.55 g/16 g N). This indicates for the particular sensitivity of lysine to the high temperature used during processing of rape seeds, which has also been demonstrated in papers by Grala et al. (1989) and Craing et al. (1981). On the other hand, rapeseed oil meal contained over 4 times less glucosinolates than seeds (5.5 vs. 22.8 μmol/g fat-free DM), which indicates that a significant amount of this components is destroyed during toasting of oil meal.

TABLE 2

Composition and digestibility of diets (Experiment 1)

	Group						SEM
Ingredients, %							
Rape seed	5	10	15	20	25	30	—
Barley	93	88	83	78	73	68	—
Vitamin-minral mixture	2	2	2	2	2	2	—
Chemical composition, %							
Dry matter	89.7	90.2	90.2	90.9	91.0	92.0	—
In dry matter:							
Ash	5.3	5.6	5.6	5.8	5.8	5.8	—
Crude protein	11.2	11.8	12.1	12.7	12.8	13.1	—
Ether extract	4.0	6.1	7.7	10.2	12.1	13.8	—
Crude fibre	4.7	4.8	5.0	5.1	5.2	5.5	—
N-free extractives	64.5	61.9	59.8	57.1	55.1	54.0	—
Total glucosinolate, mol/kg	0.6	1.2	1.8	2.4	3.0	3.6	—
Gross energy, MJ/kg	16.2	16.7	17.3	17.8	18.4	19.0	—
Apparent digestibility:							
gross energy, %	78.4^A	78.2^A	78.0^A	78.2^A	76.8^A	73.3^B	0.32
crude protein, %	71.4	71.6	71.6	71.9	70.7	69.3	0.80

A, B — $P < 0{,}01$

The level of nutrition, which differed up to 20% between each experiment, did not significantly affect the digestibility of energy and protein. No significant differences were found either between the indicator and classical methods of determining digestibility.

Increasing the proportion of RS from 5 to 30% (Table 2) and from 0 to 25% (Table 3) did not affect ($P > 0.05$) protein digestibility, which was at least 70%. A declining tendency of this parameter was observed only when the seed content exceeded 20%. The results reported by Show et al. (1990) and Ochetim et al. (1980), who observed a decrease of the protein digestibility as early as at a 15–20% seed content in the diet, were not confirmed. These authors, however, carried out their experiments on weaned piglets, more sensitive to feed quality than 50–60 kg fatteners.

TABLE 3

Composition and digestibility of diets (Experiment 2)

	Group						SEM
Ingredients, %							
Rape seed	0	5	10	15	20	25	—
Rapeseed oil meal	18	18	18	18	18	18	—
Barley	79	74	69	64	59	55	—
Vitamin-mineral mixture	3	3	3	3	3	3	—
Chemical composition, %							
Dry matter	89.6	90.1	90.3	90.8	91.1	91.1	—
In dry matter:							
Ash	5.9	6.0	5.9	6.1	6.4	6.4	—
Crude protein	15.9	16.3	16.6	17.0	17.3	17.7	—
Ether extract	2.5	4.3	6.7	8.4	9.8	12.6	—
Crude fibre	5.9	6.0	6.2	6.3	6.7	6.6	—
N-free extractives	59.4	57.5	54.9	53.0	50.9	47.9	—
Total glucosinolate, mol/kg	0.85	1.45	2.04	2.64	3.23	3.83	—
Gross energy, MJ/kg	15.9	16.5	17.1	17.9	18.5	19.3	—
Apparent digestibility %							
gross energy	77.5[a]	77.4[a]	77.0[a]	76.9[a]	74.7[b]	74.6[b]	0.43
crude protein	77.1	77.0	77.0	76.8	76.8	76.2	0.73
Metabolizability of energy, %	74.2[a]	74.2[a]	72.3[ab]	72.4[ab]	70.5[b]	70.2[b]	0.39

a, b — $P < 0{,}05$

TABLE 4

Regression equations for prediction of digestibility and metabolizability of energy and digestibility of protein for tested (b_1) and basal feed (b_2)

Expt.	n	Y	Regression coefficients b_1 (rape seeds)	b_2 (barley)	b_2 (barley + rapeseed oil meal)	R^2	se
1	12	Digestible energy, MJ/d	0.745±0.021	0.754+0.005	—	0.99	0.19
2	12		0.777±0.014	—	0.761±0.010	0.99	0.10
1+2			0.761±0.018	—	—	—	—
2	12	Metabolizable energy, MJ/d	0.684±0.024	—	0.730±0.004	0.98	0.25
1	12	Digestible protein, g/d	0.755±0.040	0.701+0.012	—	0.99	2.5
2	12		0.761±0.030	—	0.771±0.030	0.99	0.4
1+2			0.758±0.035	—	—	—	—

Model: $Y = b_1 \cdot x_1 + b_2 \cdot x_2$

As a consequence of the higher protein content in the diets used in experiment 2 and containing 18% rapeseed oil meal protein digestibility was greater by 5.8% than in experiment 1 (76.9 vs. 71.1%); this is a know relationship (Bell et al., 1987; Charmley et al., 1987).

Energy digestibility was similar in both experiments and depended to a greater extent on the amount of seed in the diet than on the level of nutrition. The energy digestibility coefficients of the diets containing 5 to 20% of raw seeds were similiar (78.2 ± 0.2%) (Expt. 1; Table 2). As the proportion of RS in the diet increased the energy digestibility in experiment 1 decreased: slightly at 25% and dropped to 73.3% at 30%. ($P \leqslant 0.01$), while in experiment 2 the energy digestibility decreased after exceeding a 15% RS content (Table 3). This difference could have been caused by the higher crude fibre content in the diets in experiment 2 than 1. The metabolizability of energy of the diets decreased as the proportion of RS increased, showing a slight tendency to change the ratio of metabolizable to digestible energy (from 0.958 to 0.941).

The energy digestibility found in this experiment was similar to the values obtained by Show et al. (1990) and Ochetim et al. (1980) for rations containing

0 to 15% of RS. When a higher proportion of seeds was used, the results differed from those reported in the literature. Increasing the amount of RS from 15 to 30% decreased energy digestibility by about 5%, while doubling the amount of seed in the study by Show et al. (1990) decreased in energy digestibility of the diet by 8%. Ochetim et al. (1980) found an approximately 5% decrease in energy digestibility when the proportion of RS in the diet increased from 10 to 20%.

The decrease in the digestibility of energy in the diets containing a high proportion of RS can be explained by their increased fat content. In our study (Expt. 1), fat digestibility of the diet with a 20% RS content (10.2% ether extract) was 66% and of the diet with a 30% RS (13.8% ether extract) was 52% ($P \leqslant 0.01$). The decreased digestibility of the ether extract was accompanied by a decline in the energy digestibility of the whole diet and, as a result, its concentration was less than expected. One of the reasons for the reduction of the digestibility of the ether extract in the diets contained a higher proportion of RS my below availability of oil contained in the seeds. Lawrance et al. (1978) showed that pigs digested fat contained in RS 14% less than the extracted oil. A similar difference was found by Askbrant et al. (1990) in studies on 5 to 7 week-old chicks fed RS or oil extracted from them and added to the meal. In can be supposed that also the increase of crude fibre content was partly responsible for the decline of the energy digestibility. It was not, however, possible to distinguish the effects of these two factors, since the amount of fat in the diet increased together with its fibre content. This is in agreement with the results of Wieseman et al. (1987), who demonstrated a curvilinear relationship between the amount of added fat and the digestible and metabolizable energy contents in the diets fed to pigs.

It was therefore not proper to introduce all the balance data into equation 1. but only those which showed a linear relationship on seed content, i.e. to 15–20%. The energy digestibility and metabolizability and digestibility of protein of RS (b_1) and the basal diet (b_2) are given in Table 4. Although in the case of RS the energy and protein digestibility coefficients were found to be somewhat higher in experiment 2 than 1, this difference was not significant. Inclusion into the basal diet (barley + RS, Expt. 1) rapeseed oil meal (Expt. 2) did not affect the digestibility of the seeds itself. The data from Table 4 were used to calculate the digestible and metabolizable energy contents in RS (22.4 and 20.1 MJ, respectively) and the digestible protein content (156 g/kg DM). The values calculated for digestible energy were similar to those found in literature, while for metabolizable energy and digestible protein they were respectively 0.6–2.0 MJ and 22–37 g lower than reported by Salo (1980) and Bourdon et al. (1990).

The results of these studies permit to draw the conclusion that when the RS content in the diet exceeds 15 to 20%, a reduction in the nutritive value of the feed should be expected. A high proportion of RS in diets reduces the digestibility and metabolizability of energy, reducing the concentration of digestible and metabolizable energy.

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STRESZCZENIE

Wartość pokarmowa nasion rzepaku podwójnie ulepszonego dla tuczników

Dwanaście wieprzków rasy pbz o średniej masie ciała 55 + 1,5 kg, żywiono mieszanką zawierającą od 5 do 30% (dośw. 1) lub od 0 do 25% surowych nasion rzepaku (dośw. 2). Strawność diet oznaczono metodą wskaźnikową (dośw. 1) lub klasyczną (dośw. 2). W doświadczeniu 2 oznaczono również metaboliczność energii. Strawność pozorna białka ogólnego nie zależała od udziału nasion rzepaku w dawce, natomiast strawność i metaboliczność energii obniżała się po przekroczeniu 15% (dośw. 2) lub 20% udziału nasion (dośw. 1). Średnie współczynniki strawności i metaboliczności energii oraz strawności pozornej białka nasion oszacowane metodą regresyjną przy ich udziale w dietach do 15 i 20% wynosiły odpowiednio: 76,1 ± 1,8%, 68,4 ± 2,4% i 75,8 ± 3,5%. Zawartość energii strawnej i metabolicznej w 1 kg suchej masy nasion wynosiła odpowiednio: 22,4 i 20,1 MJ, a zawartość białka strawnego 156 g.