EFFECT IN INDUSION OF SUNFLOWER CAKE AND ENZYMATIC PREPARATIONS DIETS FOR GROWING PIGS

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Summary. A digestibility-balance experiment was performed on 16 growing pigs (4 x 4) to determine the possibility of partial replacement of soybean meal with sunflower cake in their diets. The effects of enzymatic preparations (Energex and Bio Feed Wheat) were also analyzed. Sunflower cake constituted 5 % of diet II and 10 % of diets III and IV. Diet IV contained also enzymatic preparations. Sunflower cake added to diets did not affect crude protein digestibility. It did not reduce considerably crude fiber digestibility, either. Sunflower cake caused an increase in crude fat digestibility, with its higher content of the experimental diets. Supplementation of diet IV with the enzymatic preparations caused a significant improvement in ether extract digestibility, and a significant or a highly significant improvement in crude fiber digestibility. The level of nitrogen intake was similar in all groups. Different levels of nitrogen retention were observed in groups II and III, and its increase was noted in group IV, compared with the control group. The best utilization of retained nitrogen, in relation to nitrogen taken and digested, was found in group II (5 % of sunflower cake) Similar indices were reported for group IV (10 % of sunflower cake + enzymes). Diet supplementation with sunflower cake allowed to increase crude fat digestibility. The digestibility of the other nutrients did not change considerably. Feed enzymes improved nutrient digestibility. The substitution of sunflower protein for soybean protein did not reduce the utilization of nitrogen taken and digested.

Keywords : sunflower cake, growing pigs, digestibility, nitrogen balance.

SAULĖGRĄŽŲ RUPINIŲ IR FERMENTINIŲ PREPARATŲ ĮTAKA PARŠELIŲ RACIONAMS

Santrauka. Bandymo tikslas – įvertinti galimybę paršelių racionuose iš dalies pakeisti sojų rupinius saulėgrąžų rupiniais. Pašarų virškinamumo – balanso bandymai atlikti su 16 paršelių (4 x 4). Bandymo metu įvertinta fermentinių preparatų (*Energex ir Bio Feed Wheat*) įtaka paršelių augimui ir pašaro maisto medžiagų virškinamumui. Saulėgrąžų rupiniai sudarė 5% II raciono, 10% III ir 10% su fermentiniu preparatu IV raciono. Saulėgrąžų rupiniai neturėjo įtakos žaliųjų proteinų ir žaliosios ląstelienos virškinamumui, III ir IV racionus gavusių paršelių organizme pagerėjo žaliųjų riebalų virškinamumas. Fermentinių preparatų panaudojimas IV racione ženkliai pagerino riebiųjų lakiųjų rūgščių ir žaliosios ląstelienos virškinamumą. II ir III grupėse buvo nustatytas skirtingas azoto balansas. IV grupės azoto balansas buvo geresnis, palyginti su kontroline grupe. Geriausiai azotą pasisavino II grupės paršeliai (5% saulėgrąžų rupinių). Panašūs rezultatai nustatyti ir IV grupėje (10% saulėgrąžų rupinių ir fermentiniai preparatai). Saulėgrąžų rupiniai pagerino žaliųjų riebalų virškinamumą, kitų pašaro maisto medžiagų virškinamumui didesnės įtakos neturėjo. Fermentiniai preparatai pagerino pašaro maisto medžiagų virškinamumą. Sojų rupinių pakeitimas saulėgrąžų rupiniais įtakos azoto balansui neturėjo.

Rakatažodžiai: saulėgrąžų rupiniai, paršeliai, virškinamumas, azoto balansas.

Introduction. In Poland oil production is based either on domestic raw material, i.e. rape, or important raw material, i.e. soybean and sunflower. The nutritive value of sunflower products depends, to a high degree, on the technology of seed processing (fat removal) and oil production (high temperature, pressure). Sunflower cake is characterized by a high level of crude protein (15 % – 45 %) and ether extract (3.5 % – 38 %). The process of sunflower seed hulling is connected with nutrient loss, so the crude fiber content of final products is high (11 % – 25 %). Despite its high energy value, resulting from the presence of oil, and the lack of antinutritional compounds, lysine deficiency in sunflower protein and its high crude fiber content (two to three times higher than in the other oil-bearing plants) limit its suitability as a feed component (Lusas 1994, Albar et al. 1998, San Juan and Villamide 2000). A complex of enzymes added to diets breaks the fiber structure, especially in the case of a high hemicellulose content. This allows to increase the digestibility and assimilability of protein, fat and starch (Dierick, Decuypere 1996, Sherif et al.1997). The content of sunflower seeds or cake exceeding 5 % of the diet composition results in lower average daily gains and worse feed conversion in growing pigs (Courboulay, Massabie 1994, Lipiński, Tywończuk, 1998). Cakes – which contain more fat and crude protein than meals – are applied as energy-protein feed. Components obtained from sunflower processing must be ground and combined with ingredients rich in lysine. Sunflower cake contains oil, which enables to resign from adding animal fat to diets and to avoid technical problems accompanying this process. The results obtained by Matrai (1994) and Sorensen (1996) indicate the possibility of replacing soybean and cereal protein with protein of oil-bearing plats in diets, on condition that such diets are supplemented with synthetic amino acids and exogenous enzymes.

The aim of the present studies was to determine the possibility of partial substitution of sunflower cake for soybean meal in diets for growing pigs. The chemical

composition of sunflower cake, nutrient digestibility, nitrogen balance and the nutritive value of diets containing different amounts of sunflower cake were determined in the experiment. The possibility of increasing the suitability of sunflower cake for growing pig nutrition by diet supplementation with exogenous enzymes was also analyzed.

Material and Methods. The experiment was performed at the Department of Animal Nutrition and Feed Economy, University of Warmia and Mazury in Olsztyn. The sunflower cake used in the experiment was produced at an oil mill equipped with Krupp machines.

The basic composition of sunflower cake, diets and feces was determined by standard methods (AOAC 1990). Analysis of fiber fractions (NDF, ADF, ADL) was made by the detergent method (Soest and Wine 1967, Soest 1976). Total dietary fiber (TDF) and its soluble (SDF) and insoluble (IDF) fractions were determined by the method proposed by Asp and co-workers (1983). The gross energy content was determined in a KL-5 colorimeter. The value of metabolizable energy was calculated from the regression equation formulated by Hoffmann and Schiemann (Pig Nutrient Requirements 1993). The amino acid composition of sunflower cake protein was determined in a Czech automatic amino acid analyzer AAA T 339 M (Mikrotechna Prague), according to the user's manual and the Polish Standard "Tryptophan determination". The mineral ingredient content of fat-free sunflower cake samples was determined in an electrical, aluminum heating unit Digestion System 20 (Tecator), and by flame atomic absorption spectrometry (Unicam 939 Solar). The contents of Na and K were determined by flame photometry, using a Flapho 4 flame photometer (Carl Zeiss Jena). The phosphorus content of mineralizates was determined by the molybdate method with hydroquinone and sodium sulfite (Whiteside 1976, Rutkowska 1981).

The digestibility-balance experiment was conducted at the animal laboratory, Department of Animal Nutrition and Feed Economy, University of Warmia and Mazury in Olsztyn, by the simple balance method, on 16 young hogs kept in individual boxes. They were selected at random and divided into four groups, four head each (Table 1). Their average body weights at the beginning of the initial stage of studies were approx. 25 kg. The hogs were fed complete PP-grower diets (Table 2). The control diet contained, apart from cereals (barley + wheat) meat meal and soybean meal as the main source of protein. In the experimental diets a part of soybean meal was replaced with sunflower cake in the amount of 5 % (diet II) and 10 % (diets III and IV). Diet IV was supplemented with enzymatic preparations: Energex and Bio Feed Wheat (Novo Nordisk), in the amounts of 0.025 % and 0.035 % respectively. The preparation Energex contained the following enzymes: fungal β-glucanase, pectinase, endo β-glucanase and hemicellulase; the preparation Bio Feed Wheat contained xylanase. The enzymatic preparations were chosen on the basis of the diet composition analysis.

Table 1. **Experimental design**

Specification	Digestibility-balance experiment on growing pigs.			
PP-grower diets (Feeding groups)	I-Control	II-5 % SC	III-10 % SC	IV–10 % S.C. +E (E and BFW)
Number	4 szt.	4 szt.	4 szt.	4 szt.

Table 2. **Composition (%) and nutritive value of PP-grower (g/kg)**

Composition of diets	Diets			
	I Control	II	II	IV
Ground barley	46.87	43.85	41.70	41.64
Ground wheat	30.00	30.00	30.00	30.00
Soybean meal	15.00	13.00	10.00	10.00
Sunflower cake	-	5.00	10.00	10.00
Meat meal	5.00	5.00	5.00	5.00
L-lysine HCL 20%	0.90	0.95	1.10	1.10
DL-methionine	0.03	-	-	-
Dicalcium phosphate	1.00	1.00	1.00	1.00
Fodder salt	0.20	0.20	0.20	0.20
Premix PP-grower	1.00	1.00	1.00	1.00
Enzymatic preparations*		**-**	**-**	**0.06**
Total protein	187.0	188.8	191.1	189.5
Total digestible protein	148.3	147.5	148.3	150.1
Crude fat	21.3	26.4	32.1	32.4
Crude fiber	32.3	38.6	49.3	51.2
Metabolizable energy	14.11	13.79	13.68	13.99

***** – Energex-0.025% and Bio Feed Wheat-0.035%

Two average samples, 5 % each, were taken from feces excreted daily. One was partly dried and the other was preserved in concentrated sulfuric acid. The nitrogen content was determined by the Kjeldahl method in the

sample preserved in concentrated sulfuric acid, and the contents of the other nutrients – in the partly dried one. Urine was preserved in sulfuric acid, to maintain pH below 2.

The results of the experiment were elaborated statistically by a one-factor analysis of variance in an orthogonal design. The mean values are presented as arithmetic means ($\bar{x}$) and standard deviations (s). The significance of differences was determined by the F test and a new multiple range test (Ruszczyc 1981).

Discussion. The crude fiber content of sunflower cake samples was 25.2 % d.m. (Table 3) and was similar to that reported by other authors (Raw Material Compendium 1996, Bach Knudsen 1997, Villamide and San Juan 1998). The insoluble fraction dominated over the soluble fraction in the dietary fiber composition. In sunflower cake the IDF fraction constituted over 90 % of total dietary fiber (TDF), whereas in soybean meal its content is slightly higher than 50 %, and in rapeseed cake – 70 %. The crude protein content was 27.5 % d.m. Analysis of the amino acid composition of sunflower cake protein (Table 4) shows that it was similar to the amino acid composition of soybean meal and rapeseed cake (except for the low lysine content - 4.31 g/16g N). The high concentrations of methionine and cystine in the protein analyzed (4.38 g/16g N) are consistent with the results obtained by Canibe et al (1999) and Ami Pig (2000). The ether extract content of sunflower cake was high – 15.1 % d.m. Sunflower cake was also characterized by a low calcium content, and high levels of phosphorus and sodium (Table 5). High concentrations of copper and zinc should also be noted, as this indicates that sunflower cake is a good source of microelements. Sunflower cake contained hulls, as indicated by an increased level of crude fiber. Its crude fiber was characterized by higher – compared with rapeseed cake and soybean meal – contents of lignin and cellulose, i.e. carbohydrates incrusting cell walls. Due to a high crude fat content, sunflower cake can be a good source of easily available energy. The degree of fat removal from raw material used for oil production decides about protein concentration and the nutritive value of feed.

Table 3. **Chemical composition of sunflower cake, rapeseed cake and soybean meal (g/kg d.m.)**

Specification	Sunflower cake[1)] n=3	Sunflower cake[2)]	Rapeseed cake [3)]	Soybean meal[4)]
Dry matter g/kg	953.2	905.0	914.0	880.5
Crude ash	59.2	54.0	66.0	67.0
Crude protein	275.4	250.0	305.0	450.0
Crude fat	150.5	62.0	126.0	57.5
Crude fiber	251.5	280.0	138.0	61.5
NDF	358.5	384.0	328 0	146.0
ADF	290.6	273.0	174.0	92.0
ADL	98.2	129.0	63.0	7.0
Hemicellulose	67.7	111.0	93.0	54.0
Total dietary fiber (TDF)	428.7	430.0	461.0	303.0
Insoluble dietary Fiber (IDF)	445.3	420.0	348.0	164.0
Soluble dietary fiber (SDF)	37.4	10.0	113.0	139.0
Cellulose	192.4	144.0	172.0	85.0
N-free extractives	263.5	259.0	365.0	364.0
Organic matter	940.9	851.0	934.0	933.0
Gross energy MJ/kg d.m.	18.2	19.12	18.64	20.07

Own studies, Bell (1993) [1)]; Raw Material Compendium (1996) [2)]; Gidenne et al. 1998[3)]; Smits and Annison (1996)[4)].

Table 4. **Amino acid composition of sunflower cake protein, rapeseed cake protein and soybean meal protein (g/16g N)**

Specification	Sunflower cake [1)]	Sunflower cake [2)]	Rapeseed cake [3)]	Soybean meal [4)]
Crude protein %	25.74	38.00	33.77	43.98
Methionine	2.58	2.09	2.16	1.45
Cystine	1.81	1.68	1.60	1.52
Met+Cys	**4.38**	**3.76**	**3.47**	**2.97**
Lysine	**4.31**	**3.92**	**5.30**	**6.25**
Threonine	4.08	4.24	4.27	4.00
Tryptophan	1.11	1.47	1.30	1.31
Arginine	8.41	8.16	5.51	7.45
Isoleucine	4.34	5.29	3.67	4.56
Leucine	6.77	7.26	6.79	7.82
Valine	5.40	5.97	4.95	4.76
Histidyne	2.51	2.87	2.73	2.77

[1)]Own studies, [2), 3),4)] Raw Material Compendium 1996, Degussa 1996.

Table 5. **Mineral ingredient content of sunflower cake, rapeseed cake and soybean meal**

Specification	Units	Sunflower cake [1)]	Sunflower cake [2)]	Rapeseed cake[3)]	Soybean meal [4)]
Crude ash	g/kg	56.37	57.60	69.30	60.00
Calcium	**g/kg**	**3.75**	**3.50**	**5.90**	**2.60**
Phosphorus	g/kg	9.30	8.60	9.30	6.10
Magnesium	g/kg	4.22	4.60	4.70	2.50
Potassium	g/kg	12.96	9.00	12.10	17.90
Sodium	mg/kg	433.10	20.00	70.00	30.00
Copper	mg/kg	22.15	16.38	7.81	22.00
Manganese	mg/kg	28.82	45.90	53.01	31.00
Zinc	**mg/kg**	**77.70**	**90.00**	**55.80**	**60.00**
Iron	mg/kg	173.65	334.00	595.20	157.00

[1)]Own studies, [2), 3)]DLG 1991, [4)]NRC

The PP-grower diets used in the experiment (Table 2) were characterized by a similar crude protein content (187.0 – 191.1 g). Adding sunflower cake to the experimenttal diets resulted in an increase in ether extract content – from 21.3 g/kg in the control diet to 26.4 g/kg and over 32 g/kg in the experimental diets. It also caused an increase in the crude fiber content – from 32.3 g/kg in the control diet (I) to approx. 39.0 and 50.0 g/ kg in the experimental diets (II, III and IV). A growing sunflower cake content of the diets, accompanied by higher concentrations of crude fat and crude fiber, caused slight differences in their nutritive value.

Table 6. **Nutrient digestibility coefficients for PP-grower diets.**

Specification	Group				
	Statistics	I Control	II 5 % SC	III 10 % SC	IV 10 % S.C. +E
Digestibility coefficients (%)					
-crude protein	x	79.3	78.1	77.6	79.2
	s	0.7	1.2	0.8	1.0
-crude fat	x	51.9^{B}	58.3^{Bb}	66.7^{Aa}	73.5^{A}
	s	2.7	7.2	3.0	3.7
-crude fiber	x	24.1^{b}	24.6^{b}	23.9^{B}	30.7^{Aa}
	s	4.2	1.2	2.6	2.9
-N-free extractives	x	88.0	85.8	84.7	85.9
	s	1.0	0.6	0.6	0.3
-organic matter	x	82.7	80.3	78.8	80.5
	s	0.97	0.83	1.04	0.28
-energy	x	81.2	80.2	78.3	80.1
	s	0.57	1.17	0.67	0.25

S.C.- Sunflower cake
E- Enzymatic preparations
A, B – P<0.01
a, b - P<0.05

In the control pigs the crude protein digestibility was at a level of 79.3 % (Table 6). Adding 5 % and 10 % of sunflower cake to diets II and III reduced its digestibility to 78.1 % and 77.6 % respectively. The enzymatic preparation added to the diet containing 10 % of sunflower cake allowed to maintain the digestibility level observed in the control group, where the main source of protein was soybean meal. The differences in crude protein digestibility were not statistically significant. The digestibility coefficients obtained in the experiment for crude protein were similar to those presented by Mosenthin et al. (1997). According to Lipiec (1991), Pröll and Wiedner (1993), and Grala et al. (1998), fat removal from raw material may contribute to an increase in the digestibility of both protein and amino acids, to 79.0 – 80.0 %, or even 90.0 %. Villamide et al. (1998) and Canibe et al. (1999) report that an increase in the digestibility of nitrogen and amino acids in diets with fat-free components may result from increased concentration of crude protein. In the experimental groups crude fat digestibility increased with a growing sunflower cake content of the diets, i.e.: 5 % of sunflower cake – 58.3 %, 10 % of sunflower cake – 66.7 %, whereas in the control group crude fat digestibility was approx. 52 %. A further increase in digestibility (to approx. 74 %) was observed in group IV (10 % of sunflower cake and feed enzymes). Statistically significant differences were noted between the groups fed diets with sunflower cake (5 % and 10 %), and highly statistically significant – in relation to group IV (10 % of sunflower cake and feed enzymes). Fat obtained from sunflower cake is characterized by increased concentrations of polyunsaturated fatty acids (linoleic, linolenic and oleic), and – according to Dvorin et al. (1998) – its digestibility improves with an increase in its unsaturation. Lipiński et al. (1997), Lipiński and Tywończuk (1998), Bruździński (2000) point to an

increase in crude fat apparent digestibility with its growing content of diets. The digestibility coefficients for crude fiber in the control diet and diets containing 5 and 10 % of sunflower cake (I, II and III) were similar and varied from 23.9 to 24.6 %. An increase in its digestibility to 30.7 % was observed after diet supplementation with feed enzymes. The difference was highly significant in relation to group III, and significant in relation to group II and the control group. According to Pröll and Wiedner (1993), the digestibility of this component of sunflower meal can be much higher, and reach a level of 50 %. Close (1993), McDougall et al. (1993) and Gidenne et al. (1998) suggest that the digestibility of crude fiber and its fractions, especially in the end part of the intestine, may be affected by the botanical origin of raw material. It is also emphasized that crude protein has only a minimal negative effect on total diet digestibility (Pröll and Wiedner 1993, Gidenne et al. 1998). The digestibility of N-free extractives in the control group was 88.0 %. In the experimental groups it was slightly lower, i.e. 84.7 – 85.9 %. These differences were not statistically significant. A growing sunflower cake content of the diets caused some decrease in energy digestibility, from 81.2 % in the control group (I) to 80.2 and 78.3 in groups II and III respectively. Enzyme supplementation of diet IV allowed to obtain energy digestibility at a level similar to that noted in the control group. The differences were not statistically significant.

Partial substitution of sunflower cake for soybean meal in the experimental diets did not increase energy losses with feces and did not reduce energy digestibility considerably, which is consistent with the results presented by Pietras et al. (1996) and Barowicz (1999). Literature data show that worse energy digestibility may result from its lower concentration in a diet, caused by its higher content of crude fiber coming from sunflower cake or meal (Lipiński et al**.** 1997, Ramonet et al. 1999).

Nitrogen intake was similar in all groups, and varied from 50.87 to 52.02 g (Table 7.). However, its retention in group II (5 % of sunflower cake) was by 1.62 g higher, and in group III (10 % of sunflower cake) by approx. 1.0 g lower, compared with the control group. Enzyme supplementation of diet IV allowed to increase nitrogen retention to the level observed in group II. The growing pigs from group II (5 % of sunflower cake) and group IV (10 % of sunflower cake + enzymes) were characterized by the best utilization of retained nitrogen in relation to nitrogen taken and digested. The differences between particular groups were not statistically significant.

Table 7. **Nitrogen balance results in growing pigs**

Specification		Group			
	Statistics	I Control	II 5% S.C.	III 10% SC	IV 10% S.C. +E
Daily nitrogen balance					
N intake (g)	x	50.87	51.40	52.02	51.32
	s				
N retention(g)	x	22.23	23.85	21.33	23.76
	s	1.99	1.66	2.36	1.69
Utilization of N taken (%)	x	43.7	46.4	41.0	46.3
	s	3.9	3.2	4.5	3.3
Utilization of N digested (%)	x	55.1	59.5	52.9	58.5
	s	4.9	3.5	6.2	3.7

S.C.- Sunflower cake

E- Enzymatic preparations

The replacement of soybean protein with sunflower cake protein, supplemented with synthetic amino acids, did not reduce the utilization of nitrogen taken and digested.

The results obtained show that diet supplementation with fat, as a consequence of sunflower cake addition, may have a positive effect on nitrogen utilization. This was confirmed by the studies carried out by Barowicz and Urbańczyk (1997), and Barowicz (1999). The possibility to increase nitrogen retention and utilization in growing pigs in the case of partial substitution of oil-bearing plant extracts for soybean protein was also reported by Sobotka et al. (1995) and Lipiński et al. (1997).

Conclusion.

1. Sunflower cake obtained from raw material containing fat is characterized by a high crude fiber content, increased concentration of crude fat and good-quality protein, despite lysine deficiency.

2. The results obtained show that sunflower cake can be substituted for soybean meal in diets for growing pigs on condition that its content does not exceed 5 %. If the sunflower cake content is higher, diets must be supplemented with enzymes**.**

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