Annals of Warsaw University of Life Sciences – SGGW
Animal Science No 57 (4), 2018: 341–348
(Ann. Warsaw Univ. of Life Sci. – SGGW, Anim. Sci. 57 (4), 2018)
DOI 10.22630/AAS.2018.57.4.33

The effect of partial replacement of soybean meal protein with guar (*Cyamopsis tetragonoloba*) meal protein on the cost-effectiveness of pig fattening

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Abstract: *The effect of partial replacement of soybean meal protein with guar (Cyamopsis tetragonoloba) meal protein on the cost-effectiveness of pig fattening* Soaring demand for meat across the world has prompted an active search for alternatives to traditional protein sources. The aim of this study was to determine whether guar meal could be used as a source of protein in diets for growing-finishing pigs. The experiment was performed on 64 crossbred pigs produced by simple commercial crossbreeding [♀ (Polish Landrace × ♂ Polish Large White) × ♂ (♀ Pietrain × ♂ Duroc)]. The animals were fattened from average body weight (BW) of 30.1 kg to 112.2 kg. Control group (1) pigs were fed complete cereal-soybean meal (SBM) diets. In experimental groups 2, 3 and 4, SBM protein was partially replaced with guar meal protein in the amount of 25, 50 and 75%, respectively. All pigs were characterized by high fattening performance. Average daily gain (ADG) was highest in group 2, with no statistically significant difference relative to the control group, and significant differences relative to groups 3 and 4. The highest fattening performance was achieved in group 2 pigs fed diets containing 25% of guar meal protein, which were characterized by the highest growth rate and the lowest feed conversion ratio (FCR). An economic analysis revealed that feed cost per kg BW gain was lowest in group 2 in the 2nd stage of fattening (PLN 2.99).

Key words: finishing pigs, soybean meal, guar meal, protein, productivity, economics of pig fattening

INTRODUCTION

The availability of low-cost and high-quality and safe feed poses a challenge in animal production (Okorski et al. 2017). There is a high demand for feed additives capable of improving the palatability, nutritional value and quality of meat (Karpiesiuk et al. 2013, Lisiak et al. 2014, Lebret et al. 2015, Karpiesiuk et al. 2016). At present, the diets fed to monogastric animals, including pigs, are composed mainly of cereals and soybean meal (SBM) as the main source of protein. The significance of rational use of protein sources in pig nutrition has been recognized already in the 1970s by Grudniewska (1975). Recent years have witnessed a growing popularity of organic foods as a source of healthy and safe nutrition. This trend has contributed to an increase in the number of organic farms. Consumers around the globe have a growing interest in food products containing non-genetically modified ingredients. Pig fattening based on non-GM feeds may pose an alternative to intensive production systems that rely on GM feeds. There is a high demand for alternative low-cost sources of dietary

protein in animal nutrition. Polish researchers have been investigating local feed protein sources as an alternative to SBM (Hanczakowska and Księżak, 2012, Sońta et al. 2015, Kaczmarek et al. 2016, Sońta et al. 2016), and the use of indigenous protein crops in pig nutrition has been researched around the world (Písaříková and Zralý 2009, Crépon et al. 2010, Smith et al. 2013).

In addition to locally grown protein crops, another alternative feed protein source to SBM could be guar meal which is obtained from guar plants of the family *Fabaceae*, genus *Cyanopsis*, with the botanical name *Cyamopsis tetragonoloba* (L.) Taub (Kulthe et al. 2017). Guar is grown mainly in India, Pakistan and Africa (Saeed et al. 2017), therefore guar meal is not a popular feed ingredient in Poland. Guar is the source of guar gum, whereas guar meal is a by-product of seed processing. According to research studies conducted in the 1980s, pig diets can be supplemented with up to 6% of guar meal (Heo et al. 1987). Guar meal contains 48–52% protein and 10% dietary fiber. The widespread use of guar meal in pig and poultry diets is limited due to its relatively high fiber content and high levels of trypsin inhibitors. However, thermal processing inactivates more than 80% of trypsin inhibitors in guar meal. Guar meal is rich in arginine, but it is deficient in threonine, methionine, lysine, leucine and isoleucine (Verma and McNab 1984). Therefore, diets containing guar meal as the main protein source should be supplemented with the above amino acids. According to Humphrey et al. (2018), improved new guar meal products, although regarded as unpalatable and possibly toxic, can be a promising and inexpensive alternative protein source in animal nutrition because they contain large amounts of protein and carbohydrates. Since the introduction of the ban on the use of meat and bone meal in animal feeds, SBM has been the most popular, but also an expensive source of feed protein in Poland. In view of the above, the search for protein sources that could effectively replace SBM in animal nutrition should be continued.

The aim of this study was to determine whether guar meal could be used as a high-protein substitute for SBM in diets for finishing pigs.

MATERIALS AND METHODS

The experiment was conducted at the Animal Research Laboratory in Bałcyny, administered by the Department of Pig Breeding, University of Warmia and Mazury in Olsztyn. The experimental material comprised 64 F_2 crossbred pigs produced by simple commercial crossbreeding [♀(♀ Polish Landrace × ♂ Polish Large White) × ♂ (♀ Pietrain × ♂ Duroc)], with average initial body weight (BW) of 30.1 kg. The animals were divided into four groups by the analog method, based on BW, age and sex, and were placed in pens measuring 2.5 m × 2.5 m, with 4 pigs per pen. Before the experiment, all animals were weighed individually, marked and allocated to groups fed complete diets differing in protein source:

1 – C (control, with SBM as the main protein source);
2 – (25% of SBM was replaced with guar meal protein);
3 – (50% of SBM was replaced with guar meal protein);

4 – (75% of SBM was replaced with guar meal protein).

During the fattening period, all pigs were weighed at two-week intervals. The animals were slaughtered in a meat processing plant at average BW of 112.2 kg. The BW of pigs, feed intake and feed intake per kg BW gain (FCR) were recorded throughout the experiment.

During two-phase fattening (stage 1–30 to 70 kg BW, stage 2 – >70 kg BW), pigs were fed complete diets formulated in accordance with the Pig Nutrient Requirements, Polish edition (1993). The diets contained ground barley, ground wheat, soybean meal and guar meal in experimental groups. All diets were supplemented with commercial premix at 3 and 2.5% in the 1st and 2nd stage of fattening, respectively (Table 1). The animals had free access to water throughout the experiment.

Samples of experimental diets were analyzed for nutrient content, including crude protein, crude fat, crude fiber, dry matter and crude ash, by standard methods, at the Analytical Laboratory of the Department of Animal Nutrition and Feed Science, University of Warmia and Mazury in Olsztyn.

The cost of complete diets was calculated based on their composition (feed ingredients) in the 1st and 2nd stage of fattening, and the prices of feed components in the 1st quarter of 2018. Since all pigs were kept under identical conditions during the experiment, feed efficiency was determined according to the sim-

TABLE 1. Feed ingredients

Specification	Group			
	1	2	3	4
1st stage of fattening				
Soybean meal	21.50	16.20	10.90	5.50
Guar meal	–	4.90	9.90	14.60
Wheat	30.00	30.00	30.00	30.00
Barley	45.50	45.90	46.20	46.90
Premix*	3.00	3.00	3.00	3.00
2nd stage of fattening				
Soybean meal	15.00	11.25	7.50	3.75
Guar meal	–	3.40	6.80	10.30
Wheat	25.00	25.00	25.00	25.00
Barley	57.50	57.85	58.20	58.45
Premix*	2.50	2.50	2.50	2.50

Premix: lysine – 8.4%, methionine – 2%, methionine and cystine – 2%, threonine – 2.5%, calcium – 17%, phosphorus – 2%, available phosphorus – 4%, total sodium – 4.4%, iron – 2000 mg, manganese – 1000 mg, zinc – 3500 mg, copper – 4000 mg, iodine – 26.6 mg, selenium – 6.6 mg, vitamins: A – 350 000 IU, D_3 – 50 000 IU, E – 1 400 mg, K_3 – 30 mg, B_1 – 30 mg, B_2 – 100 mg, B_6 – 60 mg, B_{12} – 500 mcg, folic acid – 40 mg, pantothenic acid – 350 mg, niacin – 400 mg, choline chloride – 7 500 mg, amino acids: L-lysine, L-threonine, DL-methionine, phytase, antioxidants.

plified method proposed by Kim et al. (2017) where only feed cost was taken into account.

The results were processed statistically by one-way analysis of variance (ANOVA), and the significance of differences between mean values in groups was estimated by Duncan's test (Statistica 13.3).

RESULTS AND DISCUSSION

The chemical composition of diets fed to pigs is presented in Table 2. The crude protein content of diets was consistent with the protein requirements of pigs (1993), and it ranged from 17.03 to 17.70% in the 1st stage of fattening, and from 14.69 to 15.57% in the 2nd stage of fattening. The fat content of diets was relatively low, from 0.84% in the control group in the 2nd stage of fattening to 1.75% in experimental group 3 in the 2nd stage of fattening. Along with the increase in the share of guar meal, the fat content in the feed increased. The crude fiber of diets varied, but it did not exceed the maximum permissible level throughout the fattening period. All diets had similar dry matter content, ranging from 90.78 to 91.02%. The calculated concentration of metabolizable energy ranged from 12.93 MJ in the control diet in the 2nd stage of fattening to 13.48 MJ in experimental diet 3 in the 1st stage of fattening.

Mortality were not reported in any of the groups during the fattening period. In groups 3 and 4, diarrhea was noted in the initial phase of feeding diets with guar meal, but the symptoms subsided after several days of adaptation to the new feed. No treatment was required because feed intake did not decrease in groups 3 and 4, and weight loss was not observed. The fattening performance of pigs is presented in Table 3. No significant differences were found between groups during the fattening period which lasted from 97 days in group 1 to 101 days in groups 3 and 4. The average initial BW of pigs ranged from 30.1 kg in group 4 to 30.23 kg in the 1 group, and their average final BW at the end of fattening was as fol-

TABLE 2. Chemical composition (%) of pig diets

Specification	Group							
	1		2		3		4	
	1st period (g)	2nd period (G)	1st period (g)	2nd period (g)	1st period (g)	2nd period (g)	1st period (g)	2nd period (g)
Dry matter (%)	90.86	90.82	90.89	90.78	90.96	90.92	91.02	91.01
Crude protein (%)	17.09	15.35	17.40	14.69	17.70	15.57	17.03	15.39
Crude fat (%)	0.96	0.84	1.22	1.03	1.34	1.33	1.47	1.75
Crude fiber (%)	2.75	3.21	3.54	3.26	3.55	3.80	3.82	4.10
Crude ash (%)	4.28	3.62	4.37	3.59	4.19	3.65	4.42	3.19
Metabolizable energy (MJ EM)	13.00	12.93	13.16	13.04	13.33	13.15	13.48	13.27

TABLE 3. Fattening performance of pigs

Specification		Group				Total
		1	2	3	4	
Number of animals	*N*	16	16	16	16	64
Duration of the fattening period (days)						
1st stage of fattening	$\bar{x}$	49	49	54	59	23
	S	0	0	6.14	4.84	5.61
2nd stage of fattening	$\bar{x}$	48	49	47	43	46
	S	7.18	7.50	8.23	7.24	9.27
Total fattening period	$\bar{x}$	97	98	101	101	99
	S	7.18	7.5	7.5	7.50	7.56
Initial body weight (kg)	$\bar{x}$	30.2	30.1	30.1	30.0	30.1
	S	4.36	3.76	4.76	3.33	3.99
Body weight at the beginning of the 2nd stage of fattening (kg)	$\bar{x}$	72.4	71.4	70.7	70.6	71.3
	S	7.21	8.15	5.41	5.21	6.49
Final body weight (kg)	$\bar{x}$	115.3^{ab}	117.0^{cd}	109.8^{ac}	106.8^{bd}	112.2
	S	5.78	5.95	8.50	9.43	8.48
Average daily gain (g)						
1st stage of fattening	$\bar{x}$	860	844	754	697	0.789
	S	108	111	98	90	121
2nd stage of fattening	$\bar{x}$	908	946	837	862	888
	S	112	101	139	237	158
Entire fattening period	$\bar{x}$	885^{ab}	895^{cd}	792^{ac}	762^{bd}	833
	S	88	86	111	120	116
Daily feed intake (kg)						
1st stage of fattening	$\bar{x}$	2.26	2.36	2.13	2.00	2.19
2nd stage of fattening	$\bar{x}$	2.60	2.64	2.47	2.48	2.55
Entire fattening period	$\bar{x}$	2.43	2.50	2.30	2.24	2.37
Feed intake per kg body weight gain (kg)						
1st stage of fattening	$\bar{x}$	2.67	2.80	2.87	2.91	2.83
2nd stage of fattening	$\bar{x}$	2.90	2.73	3.03	3.10	2.96
Entire fattening period	$\bar{x}$	2.77	2.79	2.96	3.01	2.89

Means with the same letters differ significantly between groups $P \leq 0.05$

lows: 115.3, 117.0, 109.8 and 106.8 kg in groups 1, 2, 3 and 4, respectively. Significant differences ($P \leq 0.05$) in average final BW were noted between groups 1 and 2, and between groups 3 and 4.

As shown in Table 3, partial replacement (50 and 75%) of SBM with guar meal had an adverse effect on average daily gain (ADG) during fattening period. Pigs from the C group and group 2 were character-

ized by higher ADG ($P \leq 0.05$) compared with groups 3 and 4. In a study by Heo et al. (1987), pigs fed diets containing 3, 6, 9 and 12% of guar meal were characterized by significant differences in ADG which reached 693 and 616 g in animals receiving 9 and 12% of guar meal, respectively, compared with 757 g in the 1 group and 727 and 722 g in animals fed 3 and 6% of guar meal, respectively. Other studies investigating alternative protein sources to SBM in pig nutrition also produced satisfactory results (Thacker and Racz 2001, Roht-Maier et al. 2004). Castell and Cliplef (1993) demonstrated that growing-finishing pigs fed diets containing 12.4% of canola meal and 14.1% of pea screenings or 6.1% of canola meal and 28.3% of pea screenings achieved ADG of 850 and 880 g, respectively. Similar ADG (880 g) was reported by Müller and Bielfeldt (2013) in whose study, pigs were fed diets with rapeseed meal in the amount of 31.2 and 16.5% in the 1st and 2nd stage of fattening, respectively.

In the present study, feed intake per kg BW gain could be regarded as good. Table 3 data indicate that FCR values increased with increasing dietary inclusion levels of guar meal. However, the differences between mean values in groups were not significant.

The cost of feed per kg of BW gain was calculated based on total feed intake and the prices of feed components in the 1st quarter of 2018. The prices of complete diets fed to pigs in the 1st and 2nd stage of fattening are presented in Table 4.

The inclusion of guar meal in diets reduced the cost of feed, from PLN 5.40 in 2 group in the 2nd stage of fattening to PLN 22 in experimental group 3 in the 1st stage of fattening, compared to the diets containing soy meal. The lowest feed cost per kg body weight gain was incurred in group 2 in the 2nd stage of fattening – PLN 2.29. Although group 4 pigs received the cheapest feed, the cost of 1 kg BW gain was highest in this group – PLN 2.61 in the 1st stage of fattening and PLN 2.55 in the 2nd stage of fattening. Sońta et al. (2015) performed a simplified feed cost and production income analysis and found that the cost of 1 kg feed per 1 kg BW gain was lower in pigs fed diets containing 5% of blue lupine as a supplementary protein source.

CONLUSION

The results of this study indicate that partial (25%) replacement of SBM with guar meal in complete diets for finishing pigs had no negative effect on their productivity. The dietary supplementation with guar meal at 25% was found to be economically justified. However, the above inclusion level of guar meal, used as a substitute for SBM in pig diets, should not be exceeded because greater amounts of guar meal could adversely

TABLE 4. Price of 1 ton of complete pig diets (PLN)

Specification	Group			
	1	2	3	4
1st stage of fattening	933.80	922.20	911.60	897.20
2nd stage of fattening	847.50	838.70	830.00	822.10

affect the cost-effectiveness of pig fattening. Only a few studies have investigated the use of guar meal as an alternative protein source to SBM, therefore further research is needed to evaluate the efficacy of guar meal in pig nutrition.

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Streszczenie: *Wpływ częściowego zastąpienia białka poekstrakcyjnej śruty sojowej, białkiem pochodzącym ze śruty guar (Cyamopsis tetragonoloba) na efektywność tuczu świń.* Ze względu na rosnące spożycie mięsa, problem poszukiwania i wykorzystania zasobów białkowych jest ciągle aktualnym tematem opracowań naukowych. Celem badań była ocena możliwości wykorzystania śruty guar jako źródło białka w żywieniu tuczników. Doświadczenie przeprowadzono na 64 tucznikach mieszańcach F2 pochodzących z krzyżowania towarowego prostego [♀(♀polska biała zwisłoucha × ♂ wielka biała polska) × ♂ (♀ pietrain × ♂ duroc). Tucz prowadzono od średniej masy ciała 30,1 kg do 112,2 kg. Zwierzęta z grupy I (kontrolnej) żywione były zbożowo sojową mieszanką pełnoporcjową, natomiast w mieszankach przeznaczonych dla tuczników z grup doświadczalnych część białka poekstrakcyjnej śruty sojowej zastąpiono białkiem śruty guar w ilościach odpowiednio: 25, 50 i 75% (2, 3, 4) Uzyskano dobre wyniki tuczne, przyrosty dobowe masy ciała w grupie II były najwyższe, nie zanotowano istotnej różnicy w stosunku do grupy I, a istotnie wyższe w porównaniu do grupy III i IV. Najkorzystniejsze okazało się zastosowanie 25% udziału białka pochodzącego ze śruty guar w mieszance II, a tuczniki z tej grupy najlepiej przyrastały oraz wykorzystywały paszę. Wykonana analiza opłacalności wykazała najniższy koszt przyrostu 1 kg masy ciała u tuczników z grupy II w II okresie tuczu – 2,99 zł.

Słowa kluczowe: tuczniki, poekstrakcyjna śruta sojowa, poekstrakcyjna śruta guar, białko, cechy produkcyjne, ekonomiczna efektywność tuczu

MS received 3.07.2018

MS accepted 5.11.18

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