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ORIGINAL PAPER

FATTENING PERFORMANCE AND THE NUTRITIONAL VALUE OF MEAT FROM FINISHING PIGS FED DIETS CONTAINING DIFFERENT SOURCES OF VEGETABLE PROTEIN*

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Abstract

The aim of this study was to determine the effect of different vegetable protein sources in complete finisher diets on the fattening performance of pigs, carcass quality and the nutritional value of pork. A feeding trial was performed on 72 finishing pigs divided into 3 experimental groups, which were fed complete finisher diets containing the following sources of vegetable protein: group S – genetically modified soybean meal, group P – low-tannin pea 'Albatros' and 00-rapeseed meal, group B - high-tannin faba bean 'Nadwiślański' and 00-rapeseed meal. Performance was evaluated based on daily gains and feed efficiency for the fattening period from 65 to 105 kg body weight. Defined indicators for slaughter carcasses, chemical composition and fatty acid profile of *m. longissimus dorsi lumborum* were assessed. Significant decrease (by 5.1%) in the average daily gain of pigs was observed in group B. Backfat thickness was also significantly higher in the carcasses of group B pigs, in comparison with group S. The intramuscular fat content of *m. longissimus dorsi lumborum* was significantly lower in group P than in the remaining groups. The replacement of genetically modified soybean meal with low-tannin pea 'Albatros' contributed to a decrease in the concentrations of saturated fatty acids ($P < 0.05$) and an increase in the levels of unsaturated fatty acids in the intramuscular fat of *m. longissimus dorsi lumborum*. A more desirable UFAs / SFAs ratio and lower total cholesterol was observed in the meat of pigs fed a diet containing mixtures of seed peas and faba bean.

Keywords: pigs, genetically modified soybean meal, legumes, fattening performance, nutritional value of meat.

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INTRODUCTION

Increased awareness of the health benefits provided by various food products has prompted food companies to adapt their products to consumer requirements.

Contemporary consumers not only expect food products to meet their basic dietary needs, but also to exert beneficial health effects. This category of products, known as functional foods, is defined as follows: "A food can be regarded as functional if it is satisfactorily demonstrated to affect beneficially one or more target functions in the body, beyond adequate nutritional effects, in a way which is relevant to either the state of well-being and health or the reduction of the risk of a disease" (Diplock et al. 1999).

Meat is a rich source of nutrients, including proteins, vitamins, minerals, as well as fat and cholesterol. Animal fats should be consumed in moderation due to a high content of saturated fatty acids (SFAs). They have been found to exert adverse health effects by increasing blood cholesterol levels and contributing to the risk of cardiovascular diseases. Despite the above, the link between individual SFAs and metabolic diseases remains insufficiently investigated. According to Siri-Tarino et al. (2010), stearic acid (18:0 does not influence the total cholesterol (TC), including the level of low density lipoprotein (LDL) and high density lipoprotein (HDL) or the TC to HDL cholesterol ratio, a predicator of cardiovascular diseases. Lauric acid (12:0) increases LDL cholesterol levels, but significantly decreases the TC:HDL ratio. Meat contains less than 50% SFAs, of which 25-35% can contribute to atherosclerosis. The percentage share of unsaturated fatty acids (UFAs) varies between meat types, and it is determined at 55-57% in pork, 50-52% in beef, 50-52% in lamb and 70% in poultry (Jiménez-Colmenero et al. 2001). Breeders enhance the nutrient composition of animal diets to modify the fatty acid profile of meat, increase the proportion of UFAs and reduce the content of n-6 fatty acids (Sobotka et al. 2012).

Feeds rich in UFAs and supplemented with linseed, rapeseed and sunflower oils have a positive effect on the fatty acid profile of meat (Flis et al. 2010). It should be noted, however, that the achievement of an "ideal" fatty acid profile deteriorates animal performance.

Efforts are being made to find substitutes for soybean meal, the main source of protein in the diet of animals raised for meat. Legume species grown in Poland, such as faba beans and peas, are characterized by a lower total protein content and lower biological value of protein (measured as the essential amino acid index - EAAI) than soybean meal. Research results indicate that dietary protein inclusion levels affect the content of intramuscular fat (Wood et al. 2004, Teye et al. 2006, Fiedorowicz et al. 2016) responsible for the taste, aroma, juiciness, marbling and texture of meat. However, the correlations between the source and content of protein in animal diets and fattening performance and nutritional value have not been fully explored.

The aim of this study was to determine the effect of different vegetable protein sources in complete finisher diets on the fattening performance of pigs, carcass value and nutritional value of meat.

MATERIAL AND METHODS

A feeding trial was carried out at the Production and Experimental Station in Bałcyny on 72 hybrid [(♀ Polish Large White x Polish Landrace) x ♂ Duroc] finishing pigs divided into three groups of 24 animals each (12 gilts and 12 hogs). The experimental design is shown in Table 1.

Table 1

Design of the experiment

Specification	Experimental groups		
	S*	P	B
Vegetable protein source	genetically modified soybean meal**	low-tannin pea seeds *'Albatros'* + 00-rapeseed meal	high-tannin faba bean seeds *'Nadwiślański'* + 00-rapeseed meal
The share of vegetable protein materials in experimental mixtures (%)	13,0	15 +15	12 +15
Replacement of soybean meal (%)	0	100	100

* control group
** determined based on the information found on product labels

The animals were fattened from body weight of 65 kg to 105 kg. They were kept in groups, in pens with concrete floors covered with rubber mats in the lying area. Pens were equipped with automatic feeders and automatic nipple drinkers for wet feeding. The animals had free access to water, and they were fed *ad libitum* complete finisher diets that differed with regard to the source of vegetable protein (Table 1). In addition to high-protein components, the rations contained ground barley, ground wheat, minerals, vitamins and amino acids. Pig diets were characterized by the total protein content of 153 g kg^{-1}, total lysine content of 8.31 g kg^{-1} and metabolizable energy (EM) content of 12.80 MJ kg^{-1}. The animals were fed in accordance with Nutrient Requirements of Pigs (2014).

Performance was evaluated based on daily gains and feed conversion for the fattening period from 65 kg to 105 kg body weight (BW). At the end of the feeding trial, 30 pigs (10 from each group, a final weighing 104-105 kg) were slaughtered to evaluate carcass quality. Dressing percentage, backfat thickness, carcass lean content were determined immediately after slaughter, in accordance with the EUROP system, using a FOM 100 ultrasonic device. Measurements were performed at the level of the last thoracic vertebra, 7 cm from the dorsal midline. After 24 hours of carcass chilling at 2-4°C, ham weight and loin weight were determined, and samples of *m. longissimus dorsi lumborum* were collected to determine the proximate chemical composition of meat, including the content of dry matter, crude ash, total protein and intramuscular fat in accordance with standard methods (AOAC 2006). The fatty acid content of lipids extracted by the method proposed by Folch et al. (1957) was determined by gas chromatography using a PV 4600 device with a flame ionization detector (FID). Total cholesterol concentrations in the extracted lipid samples of *m. longissimus dorsi lumborum* were measured as described by Arneth and AlAhmad (1995).

The results were processed in the Statistica 10 PL application by one -way analysis of variance (ANOVA) and the Duncan's multiple range test.

RESULTS AND DISCUSSION

Performance and carcass quality parameters are presented in Table 2. Complete replacement of soybean meal with pea (P) and faba bean (B) seeds lowered daily gains by 1.4% and 5.1%, respectively. The above decrease was

Table 2

Fattening performance and selected carcass quality parameters (x*)

Specification	Experimental groups**			Significance level $P \leq 0.05$
	S	P	B	
Finishing period (65-105 kg body weight)				
Daily weight gain (g day^{-1})	831^{b}	819^{ab}	789^{a}	0.03
relative (%)	100	98.6	94.9	
Feed efficiency (kg feed per kg gain)	3.22	3.28	3.49	
relative (%)	100	101.9	108.4	
Carcass dressing percentage (%)	77.6	77.6	76.2	0.13
Back fat thickness (mm)	14.4^{a}	14.8^{ab}	15.5^{b}	0.05
Carcass lean content (%)	55.2	55.3	54.5	0.19
Ham weight (kg)	9.41	9.36	9.32	0.12
Loin weight (kg)	3.59	3.58	3.48	0.17

* x arithmetic mean;
** see Table 1. The figures in the tables are arithmetic means;
a, *b* – mean values in the same line with different superscript letters differ significantly at $P \leq 0.05$.

significant in the group of animals fed diets containing faba bean seeds (B). Lower daily gains prolonged the fattening period required to achieve the slaughter weight (105 kg), and increased average feed efficiency by 1.9% in group P and 8.4% in group B. Contrary results were reported by other authors (Prandini et al. 2011, Partanen et al. 2003), who found that total replacement of soybean meal with legume seeds did not impair performance at the second stage of fattening, and noted a significant improvement in the performance of animals fed faba bean seeds. According to Zijlstra et al. (2008), the faba bean content of pig diets can be increased to 30% without compromising daily gains or feed efficiency. Our results regarding pea seeds used as a substitute for soybean meal are consistent with the findings of other authors (Szabó et al. 2001, Thacker, Racz 2001, Cherenková et al. 2011).

The differences in fattening performance between our study and studies by other authors can be probably attributed to the use of seeds of different legume varieties which differ in their content of antinutritional compounds. In a study on rats, Sobczyk and Szyszkowska (2012) reported highly significant differences in average body weight gains and feed conversion between experimental groups fed high-tannin faba beans and the control group fed soybean meal. In the above study, an increase in the tannin content of faba beans led to deterioration in fattening performance.

Backfat thickness in group B was significantly higher ($P < 0.05$) than in the group of animals fed soybean meal (S). The above difference might be attributed to the prolonged fattening period in group B. The remaining carcass quality parameters were similar in all groups. Similar results were reported by other authors (Partanen et al. 2003, Cherenková et al. 2011, Milczarek, Osek 2016, Prandini et al. 2011). Stanek (1999) demonstrated that an increase in the dietary inclusion levels of pea seeds, until the complete replacement of soybean meal, led to a decrease in back fat thickness.

The effect of vegetable protein sources in pig diets on the nutritional value of meat *(m. longissimus dorsi lumborum)* was also evaluated in the present study (Table 3). The content of dry matter, crude ash and total protein was similar in all groups. Significant ($P < 0.05$) differences were observed in the intramuscular fat content. Meat from animals fed a pea-based diet (P) was characterized by a lower (2.04%) intramuscular fat content in comparison with the control group (S – 2.18%). Stein et al. (2006) and Cherenková et al. (2011) did not report differences in the intramuscular fat content between animals fed pea seeds and control animals administered a diet with soybean meal as the main protein source.

An analysis of the fatty acid profile of meat samples (Table 3) indicates that legume species significantly influences the concentrations of fatty acids, excluding polyunsaturated fatty acids (PUFAs). The use of pea seeds as a protein source in pig diets led to a significant ($P < 0.05$) decrease in the SFA levels, compared with the diet containing soybean meal. As a result, the per-

Table 3

Nutritional value of *m. longissimus dorsi lumborum* (x*)

Specification	Experimental groups**			Significance level $P \leq 0.05$
	S	P	B	
Chemical composition (%)				
dry matter	26.20	25.80	25.50	0.23
crude ash	1.12	1.11	1.11	0.09
total protein	22.90	22.53	22.17	0.11
intramuscular fat	2.18^{b}	2.04^{a}	2.19^{b}	0.04
Fatty acids *** (% of the total fatty acid pool)				
SFAs	51.84^{b}	48.52^{a}	49.13^{ab}	0.04
UFAs ****	48.16^{a}	51.42^{b}	50.87^{ab}	0.05
MUFAs	40.58^{a}	44.35^{b}	43.22^{b}	0.03
PUFAs	7.58	7.07	7.65	0.12
Ratios:				
UFAs : SFAs	0.92^{A}	1.05^{B}	1.03^{B}	< 0.01
PUFAs : SFAs	0.14	0.14	0.15	0.34
MUFAs : SFAs	0.78^{A}	0.91^{Bb}	0.87^{Ba}	< 0.01
Total cholesterol (mg 100 g^{-1})	42.25	39.07	40.63	0.06

* x – arithmetic mean;
** see Table 1. The figures in the tables are arithmetic means;
*** SFAs – saturated fatty acids, UFAs – unsaturated fatty acids, MUFAs – monounsaturated fatty acids, PUFAs – polyunsaturated fatty acids;
**** UFAs = MUFAs + PUFAs;
a, *b* – mean values in the same line with different superscript letters differ significantly at $P \leq 0.05$;
A, *B* – mean values in the same line with different superscript letters differ significantly at $P \leq 0.01$.

centage share of UFAs was significantly (P < 0.05) higher in group P than in group S. Pea seeds also had a beneficial effect on the concentrations of monounsaturated fatty acids (MUFAs) in pork. No significant differences in PUFAs content were found between groups, although PUFAs concentrations in group P were 7.58% lower than in group B and 6.75% lower than in group S. Our results do not support previous research. Milczarek and Osek (2016) demonstrated that partial replacement of soybean meal with low-tannin bean seeds in pig diets increased the intramuscular fat content and decreased PUFAs concentrations in *m. longissimus dorsi lumborum*.

The PUFA/SFA ratio is an indicator of lipid quality. The PUFA/SFA ratio recommended by the UK Department of Health (1994) is 0.4-0.5. The values noted in our study were significantly lower (0.14-0.15). In a study by Prandini et al. (2011), meat from heavy growing-finishing pigs fed diets with pea and faba bean seeds and soybean meal was characterized by a higher PUFA content and more than two-fold higher PUFA/SFA ratios

(0.39 for soybean meal, 0.33 for pea seeds and 0.33 for faba bean seeds) than those reported in our study.

Highly significant differences were reported in the ratios of unsaturated and monounsaturated fatty acids to saturated acids in all groups. The fat of animals fed diets containing pea seeds was characterized by a 11.30% higher UFA/SFA ratio and a 11.50% higher MUFA/SFA ratio compared with the control group.

No significant differences in the total cholesterol content of the analyzed meat samples were observed between groups. Cholesterol levels were lower in experimental groups B and P than in control group S, by 3.84% and 7.53%, respectively.

CONCLUSIONS

1. Soybean meal can be completely replaced with low-tannin pea seeds ‘Albatros’ and 00-rapeseed meal in pig finisher diets without compromising fattening performance or carcass quality.

2. The replacement of soybean meal with high-tannin faba bean seeds ‘Nadwiślański’ and 00-rapeseed meal in pig finisher diets had an adverse effect on daily gains, feed conversion and backfat thickness.

3. Meat from pigs fed diets containing pea seeds and faba bean characterized by a better profile of fatty acids (UFAs:SFAs, especially MUFAs:SFAs) and lower total cholesterol compared to meat from pigs fed a diet containing soybean meal.

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