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THE EFFECT OF PARTIAL REPLACEMENT OF PROTEIN CONCENTRATE IN THE DIET WITH LEGUME SEEDS ON THE FATTENING AND SLAUGHTER VALUE OF PIGS

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ABSTRACT

Pig production profitability is dependent on a number of factors that determine the extent of expenses incurred, taking into account the prices of slaughter animals, the production system and the prices of cereals included in compound feed. However, the most crucial factor is the cost of pig feeding. The aim of this work was to assess the impact of partial replacement of protein concentrate with legume seeds in complete feeds on pig growth rate and fattening efficiency under rearing conditions of a conventional farm. The polish breed crossbred fatteners were divided into two groups with different composition of the fed feed mixture. The analysis covered fattening characteristics and slaughter characteristics. In addition, the value of sales and cost of pig feeding were analysing. In this study, the fatteners fed a feed mixture with legume seeds had higher warm carcass weights, thinner backfat, and higher carcass meat content compared to pigs from control group, which ultimately translated into higher profit on fattener production. A minimum proportion of legume seeds in a feed mixture for pigs has been shown to have a significant impact on growth rate and slaughter value.

Key words: pigs, fattening profitability, fattening and slaughter assessment, feeding

INTRODUCTION

Pig production profitability is dependent on a number of factors that determine the extent of expenses incurred such as. prices for slaughter animals, farm size and fattening pig production system [Pasternak 2020, Knecht and Środoń 2013] However, the most crucial factor is the cost of pig feeding [Bocian et al. 2017, Parrini et al. 2023]. High and highly variable prices of cereals and components used for the production of feed mixtures affect the costs of pig feeding [Pepliński 2013, Lee et al. 2022].

The main source of protein in feed mixtures for pigs is imported soybean meal. It is an expensive feed, so it is possible to replace it with other plants with a similar protein level. It is therefore possible to use post-extraction rapeseed meal or dried distillery grains (DDGS) for fattening. It is true that they should be used with certain restrictions, but they also allow achieving satisfactory results in rearing pigs for fattening [Cheng et al. 2022, Choi et al. 2015, Milczarek and Osek 2014]. Another way to reduce feed costs is to use legume seeds in feeding pigs. Therefore, interest in growing and using domestic Fabaceae such as peas, horse beans as well as yellow, narrow-leaved, and white lupine has been growing [Hanczakowska and Księżak 2012, Reszka et al. 2020, Zmudzińska et al. 2020].

Results of numerous studies concerned with the effect of feeding mixtures with various proportions of legumes to fatteners have not shown a significant variation in fattening characteristics [Stein et al. 2006, Stanek et al. 2007, Bogusz and Stanek 2010, Kim et al. 2010, Kasprowicz-Potocka et al. 2013, Sońta et al. 2015, Sońta et al. 2016, Sońta et al. 2022], slaughter characteristics [Castell and Cliplef 1993, Roth-Maier et al. 2004, Stein et al. 2006, Kim et al. 2010, Hanczakowska and Świątkiewicz 2014, Śmiecińska et al. 2021], or meat quality [Bocian et al. 2016, Reszka et al. 2020, Zmudzińska et al. 2020]. On the other hand, some other

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studies investigating pig production profitability suggest that the most beneficial effects in pig production are achieved when the animals have been reared at the farm using on-farm feeds [Okularczyk 2004, Pepliński 2013, Bocian et al. 2016, 2017, Pomar and Remus 2019, De Quelen et al. 2021].

The objective of this paper was to determine the effect of partial replacement of protein concentrate with pea and yellow lupine middlings in complete feeds on pig growth rate and fattening efficiency under rearing conditions of a small conventional farm.

MATERIAL AND METHODS

No individual approval of an ethics committee was required for this study. The experimental animals were slaughtered in a registered meat processing plant. The studies were part of a routine production cycle in the swine production sector. The major research goal was to analyze the carcass and meat quality [EU 2010].

The study covered 48 F1 crossbred (Polish Large White × Polish Landrace) pigs, half of them being gilts and the other half – barrows. The animals were being kept in group pens with 12 animals per pen, in shallow litter, in compliance with well-being requirements, with unlimited access to water.

The animals were divided into two groups with 24 animals per group (50% gilts, 50% barrows in each group). The control group (C) consisted of fatteners fed a protein concentrate – based on post-extraction soybean meal, whereas the experimental group (E) were being fed a feed mixture with added 5% peas and 2.5% yellow lupine, according to standards for pig feeding [Grela and Skomiał 2020]. The mixtures were prepared on the basis of on-farm cereal middlings and concentrate. Nutritional value of 1 kg of the complete feed in groups C and E was 12.97 MJ · kg^{-1} metabolisable energy, 162 g crude protein, 11.9 g lysine (I fattening period) and 13.14 MJ · kg^{-1} metabolisable energy, 151 g crude protein, 9.7 g lysine (II fattening period), respectively (Table 1).

Fattening of the animals had started at ca. 30 kg body weight and was continued until an average body weight of ca. 111 kg was reached. Feed intake and individual animal growth rate were being monitored during the entire fattening period. Upon fattening completion, the animals were transported to an abattoir where they were slaughtered in compliance with applicable standards and provisions [Nielsen et al. 2020, EU 2005, EU 2009].

Fattener carcasses were evaluated according to the applicable EUROP classification system. Carcass meatiness was assessed using the IM-03 device authorised for use in small abattoirs. The analysis covered fattening characteristics, i.e. total body weight gain during fattening, fattening duration, daily gains, feed intake during fattening, and slaughter characteristics, i.e. warm carcass weight, slaughter yield, carcass meatiness, backfat thickness, and height of the loin muscle. In addition, the assessment covered fattener selling prices according to carcass evaluation as per the EUROP classification system and the cost of fattener feeding across the entire fattening period.

The obtained results underwent statistical processing. Arithmetic mean and standard deviation were calculated. Significance of differences between group C and E was verified using Student's *t*-test. Pearson coefficients of linear correlation between slaughter and fattening characteristics were estimated. The statistical calculations were performed using the Statistica 13.3 software [Statistica 2019].

Table 1. The nutritional value of feed mixtures

Composition of feed mixture	Feeding group			
	C Complete feed mixture Fattening period		E Mixture with pea and yellow lupine Fattening period	
	I 30 to 70 kg	II 70 to 110 kg	I 30 to 70 kg	II 70 to 110 kg
Ground barley, %	40	40	35	35
Ground wheat, %	25.1	35.3	29.8	32.3
Ground triticale, %	17	12	15	15
Pea, %	0	0	5	5
Yellow lupine, %	0	0	0	2.5
Protein concentrate[a], %	17.5	12.5	15	10
Acidulant feed, %	0.4	0.2	0.2	0.2
Metabolizable energy, MJ · kg^{-1}	12.97	13.14	12.97	13.14
Crude protein, g	162	151	162	151

[a]Component composition: post-extraction soybean meal (46%), calcium carbonate, wheat grain protein concentrate, monophosphate, sodium chloride, soybean oils and fats, magnesium oxide.
Analitical composition: metabolizable energy, 13.69 MJ; crude protein, 430 g; crude fiber, 42.8 g; crude ash, 185.8g; crude fat, 22.2 g; Ca, 42.9 g; P, 8 g; Na, 12 g; Lysine, 55 g; Methionine, 6.55 g; Tryptophan, 5.2 g; Threonine, 17.26 g.

RESULTS

Fattening performance characteristics have been shown in Table 2. At the start of fattening, body weights of animals from both groups, E and C, were comparable. However, at the end of fattening the body weights in group E were ca. 6.6 kg greater than those for group C fatteners ($P < 0.01$). Similarly, total and average daily gains were also greater in group E compared to group C ($P < 0.01$). The duration of fattening was similar in both groups. Group E showed higher feed intake across the entire fattening period and higher feed intake per 1 kg of gain when compared to group C.

Results for slaughter characteristics have been gathered in Table 3. Carcasses of pigs from group E had higher warm carcass weights, slaughter yield, height of the loin muscle, carcass meat content ($P < 0.01$) and thinner backfat ($P < 0.05$) than group C carcasses. Each carcass under assessment was classified under the most valuable categories S, E, and U (100%) as per the EUROP classification system.

The coefficients of correlation between slaughter characteristics and fattening characteristics of the pigs have been shown in Table 4. Warm carcass weight and height of the loin muscle were demonstrated to be significantly positively correlated with fattening characteristics ($P < 0.01$). Table 5 covers fattener selling prices according to post-slaughter evaluation of pork carcasses and costs of feeding these fatteners. It has been shown that the fattener selling prices were higher in group E as a result of greater warm carcass weights and higher % meat content in the carcass (only classes S and E in this group). Conversely, lower cost of fattener feeding across the entire fattening period was achieved in group C. Consequently, following a simplified economic analysis, profit has been shown to be higher in group E, consisting of pigs fed a mixture with added peas and lupine, compared to group C, fed a protein concentrate-based complete feed.

DISCUSSION

The proportion of peas and lupine used in this study in the diet for pigs, namely 5% for peas and 2.5% for lupine, is tiny when compared to doses used by other authors but it significantly increased the growth rate of the pigs. Zmudzińska et al. [2020] notice that the fattening pigs, which were offered diets based on soybean meal, had similar raw meat parameters as the pigs which were fed diets based on legumes and rapeseed as protein sources. In other experiment in which had used high percentages of peas (14.1%; 28.3%; 42.5%) in feed for growing pigs did not notice any explicitly unfavourable differences in growth rate and carcass slaughter characteristics, save for slightly lower daily weight gains in pigs fed the highest dose of peas [Castell and Cliplef 1993]. Stein and co-authors [Stein et al. 2004, Stein et al. 2006] investigated effects of feeding peas in various proportions, up to and including complete replacement of post-extraction soybean meal with peas (66%) in rations. Results of these studies have not shown any negative effect of high amounts of peas in feed mixtures on growth rates and feed conversion ratios of animals. As for the present study, higher feed intake across the entire fattening period and per 1 kg of body weight gain was achieved in pigs fed a diet with added legumes in comparison with pigs fed a complete feed, and this entailed higher costs of fattener feeding. In the study conducted by Śmiecińska et al. [2021] was found that partial (50% in grower diets) and complete (100% in finisher diets) replacement of protein from genetically modified soybean meal with protein from 00-rapeseed meal, alone or in combination with protein from faba bean seeds did not effect on carcass quality characteristics.

It transpires from a number of studies on introduction of mixtures with added peas [Stanek et al. 2007] or lupine [Bogusz and Stanek 2010, Sońta et al. 2015] in pig feeding that these legumes constitute a good substitute for imported post-extraction soybean meal. There are some concerns regarding legume feeding associated with lower content of sulphur-containing amino acids, namely methionine and cystine, and the presence of antinutritional factors and alkaloids in certain varieties of lupine [Hanczakowska and Świątkiewicz 2014, Sońta et al. 2015]. These shortcomings can be compensated for by adding appropriate agents to feeds [Abraham et al. 2019]. According to Roth-Maier et al. [2004] and Hanczakowska and Księżak [2012], a diet for pigs with 20% added lupine does not have any negative impact on pig growth and slaughter characteristics.

In this paper, it has been demonstrated that carcasses harvested from pigs fed a diet with added pea and yellow lupine seeds were characterised by more favourable slaughter value parameters. On the other hand, many studies showed similar values of slaughter characteristics for feed mixtures for pigs with added lupine seeds [Roth-Maier et al. 2004, Kim et al. 2010, Sońta et al. 2015] or peas [Stein et al. 2006] when compared to standard feeding regimes. Sobotka and Fiedorowicz-Szatkowska [2021] indicated that diet for growing pigs with 00-RSM protein combined with protein from low-tannin faba bean seeds or low-alkaloid yellow lupine seeds has no adverse effect on nutrient and energy digestibility, also and carcass and meat quality.

The relationships between slaughter value features and fattening parameters were positive in the presented studies. This concerned the hot carcass weight and the height of the tenderloin muscle. A similar relationship was noted in the research by Jacyno et al. [2003], determining the correlations between the daily gain of the

Table 2. The results of fattening

Trait	Feeding group	
	C Complete feed mixture	E Mixture with pea and yellow lupine
Number, n	24	24
Body weight, kg		
– at the beginning of fattening	30.21 ± 2.22	30.67 ± 1.99
– at the end of fattening	108.21^{A} ± 5.78	114.81^{B} ± 7.15
Total weight gain, kg	78^{A} ± 3.82	84.14^{B} ± 6.35
Fattening period, days	105 ±1.02	104 ± 2.97
Average daily weight gain, g	742^{A} ± 35	806^{B} ± 42
Feed consumption per animal throughout the fattening period, kg	199.8	240.6
Feed consumption per 1 kg of weight gain, kg/kg	2.56	2.86

Significance of differences: $^{A, B}$ $P < 0.01$, $^{a, b}$ $P < 0.05$.

Table 3. The results of slaughter traits

Trait	Feeding group	
	C Complete feed mixture	E Mixture with pea and yellow lupine
Hot carcass weight, kg	81.22^{A} ± 6.57	88.71^{B} ± 6.32
Carcass yield, %	74.98^{A} ± 2.65	77.23^{B} ± 1.08
Backfat thickness, mm	15.32^{a} ± 3.53	13.22^{b} ± 3.33
Loin muscle depth, mm	56.26^{A} ± 9.31	65.11^{B} ± 7.09
Carcass meat content, %	57.34^{A} ± 2.85	59.66^{B} ± 2.57
EUROP carcass classification system		
class S, n/%	7 / 29.17	15 / 62.5
class E, n/%	13 / 54.16	9 / 37.5
class U, n/%	4 / 16.67	–

Significance of differences: $^{A, B}$ $P < 0.01$.

Table 4. Correlation coefficients between slaughter traits and fattening characteristics of pigs

Characteristics of fattening	Characteristics of slaughter			
	Hot carcass weight	Backfat thickness	Loin muscle depth	Carcass meat content
Body weight				
– at the beginning of fattening	0.695**	0.213	0.328*	–0.045
– at the end of fattening	0.967**	0.064	0.480**	0.123
Total weight gain	0.918**	0.002	0.461**	0.163
Average daily weight gain	0.934**	-0.024	0.494**	0.195

Table 5. The value of sales and cost of pig feeding

Trait	Feeding group	
	C Complete feed mixture	E Mixture with pea and yellow lupine
Value of sale of 1 pig, PLN	524.97	563.13
Cost of feeding 1 pig throughout the fattening period, PLN	186.23	210.53
Profit, PLN	338.74	352.6

examined fattening pigs and features such as the loin eye area or the meat content in basic cuts and the entire carcass.

High prices of cereals and components used for the production of feed mixtures for pigs affect the costs of pig feeding [Okularczyk 2004, Pepliński 2013]. Higher fattening efficiency can be achieved by means of producing less expensive feeds and better conversion of the same by pigs. The use of lupine in mixtures for pigs to be reasonable due to lower prices of these mixtures and lower costs of feed consumed per 1 kg of body weight gain. It has been proven that profit on the production of fatteners fed a mixture with added narrow-leaved lupine is greater compared to that achieved for the group of pigs fed a soybean or rapeseed meal-based mixture, which is indicative of economic benefits of using narrow-leaved lupine in pig feeding [Sońta et al. 2015, Sońta et al. 2016]. In this study, the fatteners fed a feed mixture with added 5% peas and 2.5% yellow lupine had higher warm carcass weights, thinner backfat, and higher carcass meat content compared to pigs fed a complete feed, which ultimately translated into higher profit on fattener produc-

tion. Further, in more recent experiments by Sońta et al. [2022] evaluate the impact of different contributions of pea (*Pisum sativum*) on the level of selected bioactive substances in pork meat. the results indicated positive by legumes affect increased the level of bioactive components of protein fraction.

CONCLUSIONS

On the grounds of this study, conducted under conditions of a conventional farm, fattener feeding has been shown to significantly benefit from partial replacement of protein concentrate in complete feeds with a mixture with added 5% pea seeds and 2.5% yellow lupine seeds.

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WPŁYW CZĘŚCIOWEGO ZASTĄPIENIA W DIECIE KONCENTRATU BIAŁKOWEGO NASIONAMI ROŚLIN BOBOWATYCH NA WARTOŚĆ TUCZNĄ I RZEŹNĄ ŚWIŃ

STRESZCZENIE

Opłacalność produkcji trzody chlewnej uzależniona jest od szeregu czynników determinujących wielkość ponoszonych wydatków, uwzględniających ceny żywca rzeźnego, system produkcji oraz ceny zbóż wchodzących w skład mieszanek paszowych. Celem pracy była ocena wpływu częściowego zastąpienia koncentratu białkowego nasionami roślin bobowatych w paszach pełnoporcjowych na tempo wzrostu i efektywność tuczu świń utrzymywanych w warunkach chowu gospodarstwa konwencjonalnego. Tuczniki mieszańców ras polskich podzielono na dwie grupy różniące się składem skarmianej mieszanki paszowej. Analizie poddano cechy tuczne i rzeźne. Dodatkowo analizowano wartość sprzedaży oraz koszt żywienia świń. W niniejszym badaniu tuczniki żywione mieszanką paszową z udziałem nasion roślin bobowatych charakteryzowały się wyższą masą tuszy ciepłej, cieńszą słoniną i wyższą zawartością mięsa w tuszy w porównaniu z tucznikami grupy kontrolnej, co ostatecznie przełożyło się na wyższy zysk z produkcji tuczników. Wykazano, że minimalny udział nasion roślin bobowatych w mieszance paszowej dla świń ma istotny wpływ na tempo wzrostu i wartość rzeźną.

Słowa kluczowe: świnie, opłacalność tuczu, wartość tuczna i rzeźna, żywienie

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