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EFFECT OF STANDARD AND CHOICE FEEDING ON THE FATTENING RESULTS, SLAUGHTER VALUE AND WEIGHT OF INTERNAL ORGANS IN PIGS GIVEN DIETS CONTAINING RAPESEED MEAL

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ABSTRACT

The experimental fattening pigs (30-105 kg) were fed *ad libitum* diets containing rapeseed meal, according to "The Nutrient Requirements of Pigs" or the free-choice method (free access to two isoenergy diets with different protein concentrations). The experiment was performed on 24 crossbred pigs (♂ Duroc x ♀ Polish Landrace), divided into three feeding groups: group I – fed a cereal-soybean diet (1) containing 15.6% of total protein, group II – fed a cereal-rapeseed diet (2) containing 15.6% of total protein, group III – fed according to the free-choice system, with constant access to diet (3) and diet (4), containing 12.6 and 18.6% of total protein respectively. The experiment was conducted in an experimental pig house. The pigs were kept in litter boxes, two animals in each. The production results obtained were similar in all experimental groups. The feeding methods applied had no significant effect on the carcass parameters analyzed, meat quality and weights of internal organs. The average meat content of carcasses varied from 54.63 to 56.26%. The application of diets containing rapeseed meal caused an increase in the level of polyunsaturated fatty acids in backfat of the experimental pigs.

Key words: fattening (30-105 kg), feeding, free-choice method, rapeseed meal, carcass quality, weights of internal organs, fatty acids.

INTRODUCTION

The level of feed consumption and its proper utilization are the main factors determining the profitability of pig production. That is why modern feeding systems aim at increasing the percentage of lean in daily body weight gains, e.g. by appetite stimulation in growing pigs. It seems that a method conducive to optimum feed utilization, which allows to improve fattening effectiveness, is choice feeding [11]. This feeding system, different from standard ones, is expected to respond to individual needs of animals, enabling them to decide about the level of protein intake. However, the results of investigations in this field and the opinions on practical application of choice feeding have been different [6,13,21]. Braude [4], who presented the results of several experiments on choice feedings in his extensive paper, concluded that this system did not guarantee full effectiveness of pig fattening. Engelke et al. [5] did not manage to prove the advantages of choice feeding, either. The results obtained by other authors [16,17,18] indicate that this method is useful, because young pigs given two diets (a low-protein and a high-protein one) first consume both and then choose the one whose composition satisfies their nutrient requirements to the highest degree. However, the above experiments were performed only on weaners kept in individual boxes in an experimental pig house.

The available literature shows that this kind of research is relatively new in Poland [8,9,10]. The studies on choice feeding carried out in our country concern first of all cereal-soybean and cereal-lupine diets, providing no information on diets based on other ingredients, e.g. rapeseed meal. The problem of using this high-protein component has been discussed in many papers [3, 7, 15, 19], but a few authors only have focused on its application in the case of choice feeding [11].

The aim of the present studies was to determine the effect of standard and choice feeding on the fattening results, carcass quality and weights of internal organs in pigs given diets containing rapeseed meal.

MATERIALS AND METHODS

The experiment was performed at an experimental pig house belonging to the Department of Pig Breeding, University of Warmia and Mazury in Olsztyn, on 24 crossbred weaners (♂ Duroc x ♀ Polish Landrace), with initial body weights of 29.6 kg. They were divided into three experimental groups by the analogue method (taking into account their origin, sex and initial body weights):

group I – fed a cereal-soybean diet (1) containing 15.6% of total protein,
group II – fed a cereal-rapeseed diet (2) containing 15.6% of total protein,
group III – fed according to the free-choice method, with constant access to diet (3) and diet (4), containing 12.6% and 18.6% of total protein respectively.

The composition and total protein content of the experimental diets are given in Table 1. The level of total protein in diets for group III was determined by adding or subtracting 3% in relation to its level in diets for groups I and II [21]. It was assumed, following "Nutrient Requirements of Pigs" [22], that the lysine content should be 6g per 100 g of total protein, and the concentration of methionine and cystine should constitute 60% of the lysine content. Up to this level the experimental diets were supplemented with synthetic amino acids. Rapeseed meal contained in diets 2, 3 and 4 was produced at the Fat-Processing Plant in Kruszwica.

The pigs were kept in litter boxes, two animals in each. They had free access to water from automatic drinkers. Feed consumption was controlled and registered daily. The animals were weighed every two weeks. They were fed pelleted diets *ad libitum*, from automatic feeders.

The fattening pigs were slaughtered when their body weights were equal to 105 kg. A slaughter analysis was made according to the methodology applied at the Pig Performance Testing Station and all experimental stations in Poland [27]. The average meat content of carcasses was determined using ULTRAFOM. Acidity of the dorsal muscle (*musculus longissimus dorsi*), measured 45 minutes (pH_{45}) and 24 hours (pH_{24}) after slaughter with a Polish devise "Dramiński". Color lightness was determined using a spectrometer "Spekol" with a remission attachment R-45/0, at a wavelength of 560 nm. The water-holding capacity was determined by the Grau and Hamm method, modified by Pohja and Ninivara [24]. Ether extracts from complete diets and backfat, obtained by the Peisker method [34], were tested for the fatty acid content. The analysis was made using a gas chromatograph HP 6890, with helium as carrier gas.

The results were analyzed statistically by commonly applied methods, using the program STATISTICA PL for Windows.

RESULTS

The complete diets used in the experiment were characterized by a similar energy value, and their total protein content generally did not differ from that assumed in Methodology (Table 1).

Table 1. Composition of experimental diets (%)

Components	Diets			
	1	2	3	4
Ground wheat	40.0	40.0	40.0	40.0
Ground barley	39.45	35.47	46.75	24.60
Soybean meal	14.0	-	-	-
Rapeseed meal	-	18.0	6.5	29.0
Soybean oil	2.0	2.0	2.0	2.0
Salt	0.3	0.3	0.3	0.3
Dicalcium phosphate	1.0	1.0	1.0	1.0
Limestone	1.5	1.5	1.5	1.5
Vitamin-mineral premix	1.5	1.5	1.5	1.5
L-lysine	0.21	0.22	0.39	0.10
DL-Methionine	0.04	0.01	0.06	-
Nutritive value of 1 kg Crude protein	159	155	127	181
MJ EM*	12.98	12.62	12.82	12.42

* Table value.

Table 2 presents the chemical composition of rapeseed meal and the experimental diets. The fat content of the diets varied from 2.64% in diet 1 to 3.54% in diet 4. Rapeseed meal contained 34.82% of total protein, 3.56% of crude fat and 14.82% of crude fiber. According to data from Canada [2], rapeseed meal contains on average 38.3% of total protein, 4.1% of crude fat and 7.0% of ash. In the experiments described by Bourdon and Aumaitre [3], the protein content of this component ranged from 38.3 to 39.9%. The level of particular nutrients depends also on the rape variety. Adding rapeseed containing 14.82% of crude fiber to the experimental diets resulted in an increase in the content of this ingredient in diets 2, 3 and 4. Its level varied from 3.74 in diet 1 to 6.54 in diet 4. The levels of the other nutrients were similar in all experimental diets, and corresponded with the relevant standards.

Table 2. Chemical composition of experimental diets (%)

Specification	Diets				Rapeseed meal
	1	2	3	4	
Dry matter	88.36	88.06	88.09	88.54	90.77
Crude protein	15.90	15.52	12.69	18.07	34.82
Crude fat	2.64	3.30	3.11	3.54	3.56
Crude fibre	3.74	5.70	4.38	6.54	14.82
N – free extractives	60.61	58.19	62.59	54.04	29.98
Crude ash	5.47	5.35	5.32	6.33	7.59

Table 3 shows the glucosinolate content of fat-free dry matter in rapeseed meal. According to Bourdon and Aumaitre [3], the glucosinolate content of rapeseed meal ranges from 6 to 69 $\mu M \cdot g^{-1}$ of fat-free dry matter. The total glucosinolate content of the rapeseed meal examined was ca. 9.37 $\mu M \cdot g^{-1}$ of fat-free dry matter, which suggests high quality of the component used. This was also confirmed by the concentration of particular glucosinolates, which was much lower than reported by Zduńczyk [33], Jamroz and Korelski [12]. Adding rapeseed meal to diets 2, 3 and 4 caused an increase in the level of linoleic acid (C18:2) and linolenic acid (C18:3). Diet 4, containing 29% of rapeseed meal, was characterized by the highest concentration of all polyunsaturated fatty acids (Table 4).

Table 3. Glucosinolate content of rapeseed meal

Specification	Glucosinolate content (μ M·g^{-1})
Progoitrin	6.24
Napoliferin	n.d.
Glukoallizin	n.d.
Gluconapin	2.57
Glukonasturcin	0.07
4-Hydroksyglukobrassicin	0.31
Glukobrassicin	0.15
4-Metoksyglukobrassicin	n.d.
Neoglukobrassicin	0.03

n.d. - not detectable. less than < 0.01 μM·g^{-1}.

Table 4. Fatty acid composition of diets and rapeseed meal

Specification	Diets				Rapeseed meal
	1	2	3	4	
C-14	0.67	0.35	0.41	0.22	0.21
C-16	26.34	15.34	19.17	12.04	9.18
C-16:1	0.75	0.70	0.64	0.77	1.19
C-17:0	0.18	0.17	0.20	0.14	0.12
C-17:1	0.15	0.11	0.08	0.09	0.18
C-18:0	7.11	3.42	3.96	2.61	2.61
C-18:1	52.28	53.66	53.80	52.36	55.75
C-18:2	7.84	19.87	16.86	24.94	22.40
C-18:3	0.39	2.78	1.55	4.58	6.68
C-20:0	1.02	0.77	0.75	0.54	0.53
C-20:1	3.16	2.77	2.59	1.70	1.16
C-20:2	0.10	0.06	-	-	-
Saturated acids (SFA)	35.32	20.05	24.49	15.55	12.65
Unsaturated acids (UFA)	64.68	79.95	75.52	84.44	87.36
Polyunsaturated acids (PUFA)	8.33	22.71	18.41	29.52	29.08
Monounsaturated acids (MUFA)	56.34	57.24	57.11	54.92	58.28

The production results achieved by the experimental pigs are presented in Table 5. Their initial body weights were similar (on average 29.6 kg), with no significant differences between the groups. No statistical differences were noted in the final body weights of the experimental pigs, either. They varied from 104.2 kg in group II to 106.8 kg in group III. The fattening period lasted from ca. 80 days in group I to 82 days in groups II and III, fed diets with rapeseed meal.

Table 5. Fattening performance of experimental pigs

Specification		Group		
		I	II	III
Average initial body weight (kg)	$\bar{x}$	29.1	30.0	29.9
	s	4.74	3.83	3.54
Average final body weight (kg)	$\bar{x}$	106.7	104.2	106.8
	s	5.25	3.27	8.45
Days of fattening	$\bar{x}$	80	82	82
	s	8.1	5.2	10.1
Average daily gains (g)	$\bar{x}$	980	951	935
30-70 kg	s	82	63	65
70-100 kg	$\bar{x}$	968	839	950
	s	93	78	79
Average daily feed intake (kg)	$\bar{x}$	2.33	2.40	2.36
30-70 kg	s	0.24	0.21	0.23
70-100 kg	$\bar{x}$	3.21	2.99	3.21
	s	0.37	0.25	0.30
Feed / gain ($kg \cdot kg^{-1}$)	$\bar{x}$	2.37	2.52	2.51
30-70 kg	s	0.06	0.13	0.10
70-100 kg	$\bar{x}$	3.32	3.56	3.38
	s	0.23	0.17	0.25
Average daily protein intake (g)	$\bar{x}$	372	371	355
30-70 kg	s	38	32	30
70-100 kg	$\bar{x}$	514	464	469
	s	59	38	42
Protein / gain ($g \cdot kg^{-1}$)	$\bar{x}$	379	390	380
30-70 kg	s	09	20	09
70-100 kg	$\bar{x}$	530	552	496
	s	36	26	49

The average daily gains of the experimental pigs at the first stage of fattening were 980, 951 and 935 g in groups I, II and III respectively, and at the second stage – 968, 839 and 950 g. The highest daily gains were observed in group I, fed a cereal-soybean diets. However, the differences between the groups were not confirmed statistically. The fattening results, which may be described as very good, were similar to those obtained in previous experiments performed in the same pig house [8,10], and slightly better than those reported by Gill et al. [11]. In the investigations conducted by the above authors the highest daily gains (ca. 925 g) were observed in control animals, fed a diet containing 15% of rapeseed meal.

In our research we noted no significant effect of the feeding system on average daily feed consumption by the experimental pigs. The best feed conversion was observed in group I (2.37 and 3.32 $kg \cdot kg^{-1}$ at the first and second stage of fattening respectively) and the worst – in group II, fed conventionally a diet with 18% of rapeseed meal. Protein utilization per kg of body weight gain varied from 379 to 390 g at the first stage of fattening, and from 496 to 552 g at the second one. The best protein utilization was noted in group III, fed according to the free-choice method. The differences between the groups were statistically insignificant.

Selected parameters of carcass quality are presented in Table 6. These data show that different feeding systems had no significant effect on carcass quality and the physicochemical properties of meat. The carcass dressing percentage was similar in all experimental groups, and varied from 78.80 to 80.49%. The loin eye area was the biggest in group I (standard feeding). The pigs from group III (choice feeding) were characterized by the thinnest back fat – 2.19 cm. However, these differences were not statistically significant.

There were no statistical differences between the groups as regards the average meat content of carcasses, either. Carcass meatiness was very good – from 54.63 to 57.46%, reaching the highest level in group III, fed according to the free-choice method. Gill et al. [11], Nam and Aherne [21] did not observe a significant effect of choice feeding on meatiness of fattening pigs slaughtered at 90-100 kg.

Table 6. Carcass quality and weight of some internal organs

Specification		Groups		
		I	II	III
Dressing percentage (%)	$\bar{x}$	80.49	79.71	78.80
	s	1.35	2.18	0.89
Mean backfat thickness from 5 measurements (cm)	$\bar{x}$	2.53	2.34	2.19
	s	0.55	0.51	0.25
Loin eye area (cm^2)	$\bar{x}$	60.49	53.00	57.43
	s	4.02	1.97	8.29
Lean meat percentage (%)	$\bar{x}$	54.70	54.63	57.46
	s	5.51	4.81	3.38
pH_{45}	$\bar{x}$	6.57	6.49	6.66
	s	0.12	0.19	0.14
pH_{24}	$\bar{x}$	5.63	5.59	5.60
	s	0.15	0.12	0.14
Water-holding capacity (cm^2)	$\bar{x}$	6.86	7.98	7.16
	s	1.03	0.83	0.70
Colour	$\bar{x}$	27.50	27.37	28.00
	s	1.60	1.59	1.85
Average weight of spleen (kg)	$\bar{x}$	0.17	0.18	0.17
	s	0.04	0.02	0.04
Average weight of thyroid gland (g)	$\bar{x}$	8.98	9.61	10.79
	s	0.61	2.23	2.31
Average weight of liver (kg)	$\bar{x}$	1.77	1.89	1.93
	s	0.15	0.11	0.23

Table 6 shows also some physicochemical properties of meat from the experimental pigs. No statistical differences were noted between the groups as regards these properties. The lowest values of both pH_{45} and pH_{24} were observed in group II, fed a diet with 18% of rapeseed meal. These values ranged from 6.49 to 6.66 in group III 3 (pH_{45}) and from 5.59 to 5.63 in group I (pH_{24}). The values of pH indicate good quality of meat [14]. Similar pH values were given by Orzechowska et al. [23] – in their studies meat from purebred Duroc pigs was characterized by pH_{45} – 6.17 and pH_{24} –5.57.

Similar quality of carcasses was reported by Finnish authors [28], who replaced soybean meal with rapeseed meal in diets for growing-finishing pigs. The results of an organoleptic evaluation of meat were also similar. Affentranger et al. [1], who analyzed three levels of feeding (low, medium and *ad libitum*) found that meat quality was determined by the genotype. The experiment was performed on fattening pigs produced by crossing the Duroc breed. Depending on the feeding level, their carcass meatiness varied from 51.7 to 54.3%, and pH – from 5.98 to 6.05. Meat from animals fed *ad libitum* was characterized by the highest water-holding capacity (WHC).

In our experiment, the pigs from group III – given a choice between diets with different protein concentrations, did not achieve better results than those fed traditionally. A similar tendency and lack of distinct differences between standard and choice feeding as concerns production results were described by other authors [25]. This is also consistent with the results of the experiments that have been carried out so far at the Department of Pig Breeding, University of Warmia and Mazury in Olsztyn [8,9,10]. Different results were obtained by Canadian authors [21] who found that choice feeding, compared with conventional feeding, decreased the efficiency of protein deposition in the organisms of pigs.

It turned out that different feeding systems did not affect the weights of the internal organs analyzed in the experiment (Table 6). The average weights of the thyroid gland and liver varied from 8.98 g (group 1) to 10.79 g (group 3), and from 1.77 to 1.93 kg respectively. The weight of the spleen was similar in all experimental groups and amounted to ca 0.17 kg.

Despite a certain growing tendency observed in the weights of the above internal organs, connected with a higher content of rapeseed meal in the experimental diets, there were no statistical differences between the groups. Similar results were obtained by Falkowski et al. [7]. These authors did not observe a negative effect of rapeseed oil, rapeseed meal or rapeseeds contained in diets on the weights of internal organs and carcass quality.

However, they found that the liver weight was the highest (1.84 kg) in pigs fed rapeseed meal, and the thyroid gland weight (11.3 g) – in those fed rapeseeds. Kozłowski et al. [15] observed thyroid hypertrophy in pigs given diets containing 21% of rapeseed meal. According to Zduńczyk [33], pathological states of internal organs may be caused by glucosinolates. Mawson et al. [19], who presented the results of numerous studies in their paper, report that thyroid dysfunction in pigs was observed when diets contained more than 2–3 $\mu M \cdot g^{-1}$ of glucosinolates. This was also confirmed by Rotkiewicz et al. [26], Spiegel et al. [30] and Schöne et al. [29], who noted that an increase in the content of rapeseed products in diets was accompanied by an increase in the weights of the thyroid gland and liver.

Table 7 shows the chemical composition of meat of the experimental pigs. The levels of particular chemical components were similar in all groups. The content of protein and fat ranged from 21.88 (group II) to 22.20% (group I), and from 1.25 (group I) to 1.42% (group III) respectively.

Table 7. Chemical composition of meat of experimental pigs (%)

Specification		Group		
		I	II	III
Dry matter	$\bar{x}$ s	24.98 0.51	24.51 0.64	24.79 0.39
Crude protein	$\bar{x}$ s	22.20 0.24	21.88 0.43	22.01 0.17
Crude fat	$\bar{x}$ s	1.25 0.35	1.34 0.45	1.42 0.43
Crude ash	$\bar{x}$ s	1.19 0.06	1.16 0.04	1.19 0.04

An increase in the concentration of fatty acids: linoleic (C18:2) and linolenic (C18:3) in diets had a positive effect on an increase in their level in backfat of the experimental pigs (Table 8), which varied from 7.49% (C18:2) and 1.60% (C18:3) in group I to 11.17% (C18:2) and 1.84% (C18:3) in group III. The differences between the average contents of these acids were confirmed statistically at a level α=0.05. Similar differences were noted in the case of oleic acid (C18:1), whose concentration ranged from 42.34% in group I to 43.79% in group III.

Table 8. Fatty acid composition of backfat

Fatty acids	Group		
	I	II	III
C-12:0	1.01	0.08	0.09
C-14:0	1.48	1.39	1.42
C-16:0	25.89	24.61	24.42
C-16:1	2.20	2.23	2.31
C-17:0	0.29	0.25	0.28
C-17:1	0.26	0.24	0.28
C-18:0	15.83^{a}	13.67^{b}	12.91^{b}
C-18:1	42.34	43.26	43.79
C-18:2	7.49^{b}	10.96^{a}	11.17^{a}
C-18:3	1.60^{b}	1.82^{a}	1.84^{a}
C-20:0	0.22	0.20	0.21
C-20:1	0.91	0.87	0.85
C-20:2	0.48	0.43	0.43
Saturated acids (SFA)	44.72	40.20	39.33
Unsaturated acids (UFA)	55.28	59.81	60.67
Polyunsaturated acids (PUFA)	9.57^{b}	13.21^{a}	13.44^{a}
Monounsaturated acids (MUFA)	45.71	46.60	47.23

ab - $\propto$ = 0.05.

An increase in the level of unsaturated fatty acids (especially oleic and linolenic) both in backfat and loin of pigs fed diets containing rapeseed products was also observed by Migdał et al. [20]. Warants et al. [31,32], in their extensive reports on polyunsaturated fatty acids, emphasize that the level of these acids in diets given to pigs affects considerably their concentration in the final products, and the quality of pork.

CONCLUSIONS

1. The results of fattening and carcass evaluation were very good in all experimental groups.
2. The system of feeding (standard or free-choice - diets with rapeseed meal) had no significant effect on the fattening results, carcass parameters, quality and chemical composition of meat.
3. Adding rapeseed meal to the experimental diets resulted in an increase in the concentration of polyunsaturated fatty acids in backfat of the experimental pigs.

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