ORIGINAL PAPER

EFFECTS OF PROTEIN-XANTHOPHYLL (PX) CONCENTRATE OF ALFALFA ADDITIVE TO CRUDE PROTEIN-REDUCED DIETS ON NITROGEN EXCRETION, GROWTH PERFORMANCE AND MEAT QUALITY OF PIGS*

WPŁYW DODATKU KONCENTRATU BIAŁKOWO-KSANTOFILOWEGO (PX) Z LUCERNY DO MIESZANEK O ZMNIEJSZONYM POZIOMIE BIAŁKA OGÓLNEGO NA WYDALANIE AZOTU, EFEKTY PRODUKCYJNE I JAKOŚĆ MIĘSA TUCZNIKÓW

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ABSTRACT

The influence of protein-xanthophyll (PX) concentrate of alfalfa supplement to crude protein-reduced diets was examined in relation to nitrogen excretion, performance parameters and pig meat quality. The investigations included 60 growers (PL x PLW) x Duroc crossbreeds assigned to 3 groups. The conclusion is that there is a large potential to decrease nitrogen emission to the environment by 10% lowering of dietary crude protein intake along with reduced animal growth rate and elevated mixture utilization. Inclusion of a protein-xanthophyll concentrate (PX) of alfalfa to the diet is likely to diminish disadvantageous productive parameters arising from limiting of total crude protein level in relation to the requirements of pigs feeding norms [1993]. At the same time, it improves feed nitrogen utilization and reduces noxious odour emissions from a piggery. The components of a protein-xanthophyll concentrate (PX) contribute to increased liver and kidney weight.

Key words: fatteners, feeding, protein content, PX from alfalfa, meat, fatty acids

STRESZCZENIE

Celem badań było określenie wpływu dodatku koncentratu białkowo-ksantofilowego (PX) do mieszanek o zmniejszonym poziomie białka ogólnego na wzrost i wykorzystanie paszy, bilans azotu oraz cechy fizyko-chemiczne mięsa wieprzowego. Badania dokonano na 60 warchlakach mieszańcach (pbz x wpb) x Duroc podzielonych na 3 grupy. W podsumowaniu należy podkreślić możliwość ograniczenia wydalania azotu do środowiska poprzez 10% ograniczenie poziomu białka w diecie tuczników przy jednoczesnym spadku tempa wzrostu zwierząt i zwiększonym zużyciu mieszanki. Dodatek koncentratu białkowo-ksantofilowego (PX) z lucerny może zniwelować niekorzystne efekty produkcyjne związane z ograniczeniem poziomu białka surowego w stosunku do Norm Żywienia Świń [1993] przy jednoczesnej poprawie wykorzystania azotu paszy i zmniejszeniu nieprzyjemnych zapachów odorowych w chlewni. Zawarte w koncentracie białkowo-ksantofilowym (PX) substancje przyczyniają się do zwiększenia masy wątroby i nerek.

Słowa kluczowe: tuczniki, żywienie, poziom białka, PX z lucerny, mięso, kwasy tłuszczowe

DETAILED ABSTRACT PO POLSKU

Celem badań było określenie wpływu dodatku koncentratu białkowo-ksantofilowego (PX) do mieszanek o zmniejszonym poziomie białka ogólnego na wzrost i wykorzystanie paszy, bilans azotu oraz cechy fizyko-chemiczne mięsa wieprzowego. Badania dokonano na 60 warchlakach mieszańcach (pbz x wpb) x Duroc podzielonych na 3 grupy po 10 loszek i 10 wieprzków w każdej o masie początkowej 25 kg, tuczonych do 110 kg. Tuczniki utrzymywane grupowo po 4 sztuki w boksie pobierały do woli mieszanki sypkie z automatów paszowych, wodę zaś z poideł automatycznych. Zwierzęta grupy kontrolnej (I) żywiono mieszankami pełnoporcjowymi, przy czym zawartość białka ogólnego i aminokwasów była zgodna z zaleceniami norm żywienia świń [1993]. Mieszanki dla grup doświadczalnych (II i III) zawierały zmniejszony o 10% poziom białka ogólnego i aminokwasów: lizyny, metioniny z cystyną oraz argininy i tryptofanu. W grupie III zastosowano 3% dodatek koncentratu PX z soku z lucerny zamiast śruty poekstrakcyjnej sojowej. Zwierzęta były ważone trzykrotnie, przy systematycznej kontroli pobrania paszy. Badania bilansowe wykonano w klatkach metabolicznych na 6 wieprzkach z grupy przy masie ciała 40-45 i 80-85 kg. Wykonano ocenę wartości rzeźnej tusz, zważono wątrobę, serce i nerki, zaś w próbach mięśnia longissimus oznaczono cechy fizyczne i chemiczne, w tym profil kwasów tłuszczowych.

Najwyższe przyrosty dzienne (785 g) uzyskały tuczniki w grupie kontrolnej, a najniższe w II (721 g). Dodatek PX zwiększył przyrosty w grupie III do 762 g w porównaniu do grupy II. Podobne tendencje stwierdzono przy wykorzystaniu paszy, przy czym dodatek PX poprawił ten wskaźniki o prawie 6% w stosunku do grupy II. Obniżenie o 10% poziomu białka ogólnego (w mieszankach dla zwierząt grupy II i III) w stosunku do zaleceń Norm Żywienia Świń [1993] przyczyniło się do istotnego zmniejszenia wydalania azotu z kałem i moczem w granicach 7,2 – 7,4% w porównaniu do kontroli (grupa I). Tuczniki zatrzymały też mniej azotu w ciele: 36,2 g wobec 37,1 g w pierwszym okresie tuczu (PT-1) oraz 56,0 g wobec 60,6 g w drugim okresie tuczu (PT-2), odpowiednio w II i I grupie. Jednak absorpcja azotu w stosunku do pobranego z paszy była wyższa (53,2% vs. 51,3%) w okresie PT-1, zaś niższa w PT-2 (46,9% vs. 47,4%). Nie stwierdzono istotnych zmian masy wątroby, serca i nerek oraz we wskaźnikach analizy rzeźnej tusz, choć dało się zauważyć nieznaczną tendencję do zmniejszenia ilości mięsa w tuszy w grupie II w porównaniu do I. Zmniejszeniu uległ wskaźnik TBARS z 1,13 w grupie kontrolnej do 0,93 mg/kg mięśnia w grupie II. W składzie kwasów tłuszczowych tłuszczu mięsa stwierdzono wzrost udziału jednonienasyconych kwasów (MUFA) w grupie II, gdzie zastosowano mieszankę o obniżonym poziomie białka ogólnego. Dodatek koncentratu białkowo-ksantofilowego (PX) z lucerny w ilości 30 g w 1 kg mieszanki przyczynił się do poprawy wykorzystania azotu paszy o 4,4-4,5%, istotnego ($p \leq 0,05$) zwiększeniu mięsności tuszy, ale także i masy wątroby (1344,7 g w grupie II i 1517,8 g w III) i nerek, odpowiednio 154,8 g i 194,6 g. W składzie kwasów tłuszczowych tłuszczu mięsa w grupie III stwierdzono wzrost udziału wielonienasyconych kwasów tłuszczowych (PUFA) w porównaniu do grupy II.

W podsumowaniu warto podkreślić możliwość ograniczenia wydalania azotu do środowiska poprzez 10% ograniczenie poziomu białka ogólnego w diecie tuczników żywionych według Norm Żywienia Świń [1993], ale przy jednoczesnym spadku tempa wzrostu zwierząt i zwiększonym zużyciu mieszanki. Dodatek 30 g koncentratu białkowo-ksantofilowego (PX) z lucerny do 1 kg paszy może zniwelować niekorzystne efekty produkcyjne związane z ograniczeniem poziomu białka surowego w stosunku do Norm Żywienia Świń [1993] przy jednoczesnej poprawie wykorzystania azotu paszy i zmniejszeniu nieprzyjemnych zapachów odorowych w chlewni. Zawarte w koncentracie białkowo-ksantofilowym (PX) substancje przyczyniają się do zwiększenia masy wątroby i nerek.

INTRODUCTION

The primary aim of pig nutrition is to optimize the production parameters (body weight gains, feed utilization ratio, meatiness) but recently nutritional strategies have been also considered as a large potential to reduce the environmental load generated by the animal production [9, 10]. Hence, biogen emission to the atmosphere may be lowered by a carefully balanced dietary nutrients [2, 12, 16], employment of phase-feeding program [20], individual fattening of gilts, hogs and boars [10, 12] as well as application of various feed additives [5, 6, 11, 19]. Besides, the efforts are made to reduce a crude protein content in the diet with/without synthetic amino acid supplementation. For example, the work by Lenis and Schutte [13] implied that a protein content of a typical swine ration could be reduced by three percentage points (e.g., from 16% to 13%) by replacing soybean meal with synthetic amino acids and corn without any negative effects on animal performance. Even a less comprehensive approach, such as simply replacing some of a corn and soybean meal diet with synthetic lysine, has been shown to lower dietary protein by 1.5% [17]. Such reductions could exert a large impact on N excretion in

Table 1. Composition (%) and nutritive value of growing-finishing pig mixtures
Tabela 1. Skład i wartość pokarmowa mieszanek dla tuczników

Specification Wyszczególnienie	Feeding groups Grupy żywieniowe		
	I - control	II	III - 3% PX
Growing period - PT-1 from 25 to 70 kg Pierwszy okres tuczu – PT-1 od 25 do 70 kg			
Wheat - Pszenica	31.0	37.0	37.0
Barley - Jęczmień	50.0	50.0	50.0
Soybean meal – Poekstrakcyjna śruta sojowa	12.0	7.0	4.0
Protein concentrate – Mieszanka uzupełniająca	6.0	5.0	5.0
Soybean oil – Olej sojowy	0.9	0.9	0.9
Acidifier - Zakwaszacz	0.1	0.1	0.1
Protein-xanthophylls (PX) concentrate of alfalfa Koncentrat białkowo-ksantofilowy (PX) z lucerny	-	-	3.0
Total- Ogółem	100.0	100.0	100.0
Content in 1 kg of mixture – Zawartość w 1 kg mieszanki:			
Crude protein – Białko ogólne, (g kg^{-1})	171.4	154.6	155.1
Lysine - Lizyna, (g kg^{-1})	9.2	8.3	8.4
Methionine + cystine – Metionina + cystyna, (g kg^{-1})	6.2	5.6	5.6
EM, (MJ kg^{-1})	12.63	12.68	12.69
Finishing period - PT-2 from 70 to 110 kg Drugi okres tuczu – PT-2 od 70 do 110 kg			
Wheat - Pszenica	36.0	41.0	41.0
Barley - Jęczmień	50.0	50.0	50.0
Soybean meal – Poekstrakcyjna śruta sojowa	7.5	4.5	1.5
Protein concentrate – Mieszanka uzupełniająca	6.0	4.0	4.0
Soybean oil – Olej sojowy	0.4	0.4	0.4
Acidifier - Zakwaszacz	0.1	0.1	0.1
Protein-xanthophylls (PX) concentrate of alfalfa Koncentrat białkowo-ksantofilowy (PX) z lucerny	-	-	3.0
Total- Ogółem	100.0	100.0	100.0
Content in 1 kg of mixture:			
Crude protein – Białko ogólne, (g kg^{-1})	151.5	135.7	136,1
Lysine - Lizyna, (g kg^{-1})	7.53	6.74	6.75
Methionine + cystine – Metionina + cystyna, (g kg^{-1})	4.54	4.11	4.12
EM, (MJ kg^{-1})	12.61	12.63	12.65

manure. Schutte et al. [18] and Monge et al. [14] both found that for each percentage point that N is reduced in the feed, N excretion is reduced by 10% to 11%. Van der Peet-Schwering et al. [20] reported that decreasing protein by 1% limited ammonia losses by 10% to 11%. Out of various feed additives, organic acids, herbs and plant preparations are worth considering [5, 10, 21, 23]. Den Brok et al. [5] showed that use of benzoic acid improved feed conversion from 2.92 to 2.83, while reduced ammonia emissions by 40%. The studies by Bourdon et al. [3] and Yen [23] indicate the purposefulness of the dried alfalfa inclusion into fatteners` diet that results in high productive effects and decreased amount of nitrogen released to environment. Some research reports highlight the application of protein-xanthophyll (PX) concentrate in animal nutrition that allows to obtain proper performance parameters, good-quality carcass and pork as well as higher efficiency of feed N utilization [3, 8].

The objective of the present research was to determine the influence of protein-xanthophyll (PX) concentrate supplement to the diets with a limited crude protein level on pig growth performance, feed conversion ratio, nitrogen balance and physicochemical properties of pork.

MATERIAL AND METHODS

The investigations included 60 growers (PL x PLW) x Duroc crossbreeds assigned to 3 groups, 10 gilts and 10 boars each. The initial body weight of animals was 25

Table 2. Performance and N-balance of pigs fed the diets with 3% protein-xanthophylls (PX) concentrate of alfalfa
Tabela 2. Efekty produkcyjne oraz bilans azotu tuczników żywionych paszą z 3% udziałem koncentratu białkowo-ksantofilowego (PX) z lucerny

Specification Wyszczególnienie	Feeding groups Grupy żywieniowe			SEM
	I - control	II	III – 3% PX	
Average daily gains – Przyrosty dzienne (25-70 kg), (g)	654[a]	582[b]	626[a]	25.4
Average daily gains – Przyrosty dzienne (71-110 kg), (g)	915[a]	859[b]	896[a]	34.6
Feed conversion ratio (25-70 kg), (kg kg^{-1} gains) Wykorzystanie pasz (25-70 kg), kg kg^{-1} przyrostu	2.40[a]	2.89[b]	2.68[ab]	0.11
Feed conversion ratio (71-110 kg), (kg kg^{-1} gains) Wykorzystanie pasz (71-110 kg), kg kg^{-1} przyrostu	3.14[a]	3.53[b]	3.36[ab]	0.09
N intake – Pobranie N (25-70 kg), (g d^{-1})	42.70[a]	41.13[ab]	40.39[b]	0.14
N intake – Pobranie N (71-110 kg), (g d^{-1})	68.88[a]	63.29[b]	62.86[b]	0.23
Urine production –Produkcja moczu (25-70 kg), (ml d^{-1})	2568.2[a]	2512.5[a]	2853.7[b]	28.40
Urine production -Produkcja moczu (71-110 kg), (ml d^{-1})	3527.4[a]	3496.6[a]	3912.9[b]	34.46
N excreted in urine – Wydalanie N w moczu (25-70 kg), (g d^{-1})	15.22[a]	14.31[ab]	13.53[b]	0.75
N excreted in urine - Wydalanie N w moczu (71-110 kg), (g d^{-1})	27.94[a]	26.36[ab]	25.12[b]	0.92
Production wet faeces – Produkcja kału mokrego (25-70 kg), (g d^{-1})	486.3	478.2	481.4	8.01
Production wet faeces - Produkcja kału mokrego (71-110 kg), (g d^{-1})	646.3	658.0	651.2	11.23
N excreted in faeces – Wydalanie N w kale (25-70 kg), (g d^{-1})	5.58[a]	4.96[b]	4.45[c]	0.21
N excreted in faeces - Wydalanie N w kale (71-110 kg), (g d^{-1})	8.29[a]	7.27[b]	6.96[b]	0.32
Total N excreted – Wydalanie N ogółem (25-70 kg), (g d^{-1})	20.80[a]	19.27[b]	17.98[c]	0.41
Total N excreted – Wydalanie N ogółem (71-110 kg), (g d^{-1})	36.23[a]	33.63[b]	32.08[b]	0.68
Nitrogen retained – Retencja N (25-70 kg), (g d^{-1})	37.12[a]	36.17[ab]	35.94[b]	0.56
Nitrogen retained – Retencja N (71-110 kg), (g d^{-1})	60.59[a]	56.02[b]	55.90[b]	0.72
Nitrogen absorption – Absorpcja N (25-70 kg) (g d^{-1})	21.90	21.86	22.42	0.34
Nitrogen absorption – Absorpcja N (71-110 kg), (g d^{-1})	32.65[a]	29.66[b]	30.78[ab]	0.46
Nitrogen absorption – Absorpcja N (25-70 kg), (% N intake) – (% N pobranego)	51.29[c]	53.15[b]	55.51[a]	0.57
Nitrogen absorption – Absorpcja N (71-110 kg), (% N intake) – (% N pobranego)	47.40[b]	46.86[b]	48.97[a]	0.49

a, b – values in the same rows with different letters differ significantly ($P \leq 0.05$)
a, b – wartości w wierszu oznaczone różnymi literami różnią się istotnie przy $p \leq 0.05$

kg and they were fattened until the slaughter weight of 110 kg was reached. The fatteners were penned, 4 pigs each, the mixtures were supplied from dry self-feeders ad libitum and water from bottle-like drinkers. The animals from the control group (I) were fed full ration diets, crude protein and amino acid contents complied with the feeding standard requirements for pigs [15]. Mixtures for the experimental groups (II and III) had decreased by 10% crude protein level including the essential amino acids. In the group III, the diet was formulated to contain a 3% PX concentrate of alfalfa juice to replace soybean meal. Composition and nutritive value of diets are shown in Table 1. The content of nutrients and amino acids were determined by AOAC [1] methods. The animals were weighed three times. Feed intake was determined. The balance examinations were conducted in the metabolism

Table 3. Carcass slaughter value and physicochemical traits of *longissimus* muscle
Tabela 3. Wartość rzeźna tuszy oraz cechy fizyko-chemiczne mięśnia *longissimus*

Specification Wyszczególnienie	Feeding groups Grupy żywieniowe			SEM
	I - control	II	III - 3% PX	
Body weight by slaughter - Masa ubojowa, (kg)	109.5	108.1	109.7	1.23
Cold dressing field - Wydajność rzeźna zimna, (%)	79.2	79.6	79.2	0.87
Average backfat thickness – Średnia grubość słoniny:				
over the shoulder – nad łopatką, (mm)	2.76	2.61	2.79	0.11
on the midback – na grzbiecie, (mm)	1.58	1.60	1.59	0.05
on the rump, mean of 3 measurements, (mm) na krzyżu, średnia z 3 pomiarów, (mm)	1.38	1.48	1.47	0.04
average of 5 measurements – średnia z 5 pomiarów, (mm)	1.70	1.72	1.76	0.05
Weight of ham – Masa szynki, (kg)	8.92	8.67	8.96	0.45
Lean of ham – Mięso szynki, (%)	63.8	62.3	63.2	1.68
Loin eye area – Powierzchnia oka polędwicy, (cm^2)	42.7^{ab}	41.8^{a}	43.1^{b}	0.47
Weight of liver – Masa wątroby, (g 100 kg^{-1} BW-MC)	1396.4^{a}	1344.7^{a}	1517.8^{b}	59.8
Weight of heart – Masa serca, (g 100 kg^{-1} BW-MC)	349.5	357.3	381.4	14.3
Weight of kidney – Masa nerek, (g 100 kg^{-1} BW-MC)	156.7^{a}	154.8^{a}	194.6^{b}	12.8
Drip loss - Wyciek naturalny, (%)	1.0	1.1	1.0	0.02
Cooking loss - Wyciek termiczny, (%)	26.7^{a}	28.1^{b}	27.6^{ab}	0.31
WHC - Woda luźna, (mg)	47.1	45.5	46.6	0.19
M/T*	41.7	42.2	42.6	0.21
Shear force - Siła cięcia, (N max)	69.5^{a}	76.2^{b}	73.5^{ab}	0,74
Work - Praca, (J)	0.26	0.30	0.29	0.03
pH_1	5.78	5.71	5.82	0.05
pH_{24}	5.70	5.50	5.67	0.06
EC_1, (mS cm^{-1})	5.1	4.7	4.9	0.10
EC_{24}, (mS cm^{-1})	12.4	12.7	12.8	0.05
TBARS, (mg kg^{-1})	1.13^{b}	0.93^{a}	0.87^{a}	0.11
Haem pigments - Barwniki hemowe, (mg kg^{-1})	90.8^{a}	87.9^{a}	98.3^{b}	1.03
Haem iron - Żelazo hemowe, (mg kg^{-1})	8.0^{a}	7.7^{a}	$8,7^{b}$	0.21

a, b – values in the same rows with different letters differ significantly ($P \leq 0.05$)
a, b – wartości w wierszu oznaczone różnymi literami różnią się istotnie przy $p \leq 0.05$

cages where six growers from a group were placed (body weight 40-45 and 80-85 kg). Evaluation of pig carcass slaughter value was made; besides, the liver, heart and kidney were weighed and finally, physicochemical properties determined in the longissimus muscle samples, in that a fatty acid composition.

The pH and electrical conductivity were measured by means of pork quality meter (PQM). The measurements were performed 1 h and 24 h post slaughter (pH_1, EC_1 and pH_{24}, EC_{24}). Meat color was evaluated after 30 min-exposure by means of color saturation index Minolta CR-310. Water-holding capacity of meat was established by drip loss measurement (difference in the sample weight determined before and after 24 h cold storage) and thermal drip (difference in the sample weight before and after 60 min. - thermal treatment at 70^0 C). A homogenized meat weighed portion of 0.3 g subjected to 2 kg - weight pressure for 5 minutes wetted the Whatman No 1 filter paper, thus marking the drip area (cm^3). Then a free water content was calculated. The drip area was estimated using the scanned images with computer image analysis system MultiScan Base ver. 14 application.

The TBARS index was determined according to the method by Witte et al. [22] at 530 nm wavelength on a spectrophotometer Cary 300 Bio. Haem pigments were established after Hornsey [7] procedure at 640 nm wavelength. Meat tenderness evaluation was carried out by means of one-column resistance test machine Zwick/Roell Proline BO, 5 to define maximum shear force (N) and shear behavior (J). Fatty acid determination was

Table 4. Fatty acid composition (%) in *longissimus* fat muscle of fatteners
Tabela 4. Skład kwasów tłuszczowych (%) w tłuszczu mięśnia *longissimus*

Item Wyszczególnienie		Feeding groups Grupy żywieniowe			SEM
		I - control	II	III – 3% PX	
Lauric - Laurynowy	12:0	0.07	0.07	0.07	0.02
Myristic - Mirystynowy	14:0	1.27	1.25	1.30	0.11
Palmitic - Palmitynowy	16:0	24.91	24.41	25.60	1.26
Palmitoleic - Palmitynoleinowy	16:1, n-7	2.89	3.32	2.84	0.21
Stearic - Stearynowy	18:0	14.60[b]	13.74[ab]	13.09[a]	0.65
Oleic - Oleinowy	18:1, n-9	43.08	44.42	44.38	1.98
Vaccenic - Wakcenowy	18:1, n-7	3.95	4.26	4.14	0.22
Linoleic – Linolowy	18:2, n-6	6.15	5.55	5.63	0.38
Linolenic - Linolenowy	18:3, n-3	0.45[a]	0.40[a]	0.63[b]	0.08
Arachidic - Arachidowy	20:0	0.18	0.16	0.22	0.03
Gadoleic - Gadolenowy	20:1, n-11	0.84	0.79	0.76	0.04
Eicosadienoic - Eikozadienowy	20:2, n-6	0.21	0.28	0.26	0.03
Arachidonoic - Arachidonowy	20:4, n-3	0.41	0.43	0.43	0.04
Docosadienoic - Dokozadienowy	22:2, n-6	0.29	0.35	0.37	0.04
Other FA – Pozostałe kt		0.70[a]	0.57[a]	0.28[b]	0.11
Total - Ogółem		100.00	100.00	100.00	0.00
Saturated FA – Nasycone kt		41.03	39.63	40.28	1.57
Monoenic FA – Jednonienasycone kt		50.76[a]	52.79[b]	52.12[b]	1.16
Polyunsaturated FA – Wielonienasycone kt		7.51[a]	7.01[b]	7.32[ab]	0.74

a, b – values in the same rows with different letters differ significantly ($P \le 0.05$)
a, b – wartości w wierszu oznaczone różnymi literami różnią się istotnie przy $p \le 0.05$

performed using the gaseous chromatography method on a Varian CP-3800 chromatograph. The chromatograph operating conditions for fatty acid separation were: capillary column CP WAX 52CB DF 0,25 mm of 60 m length, gas carrier - helium, flow rate – 1.4 ml/min, column temperature 120^0 C gradually increasing by 2^0 C/min, determination time – 127 min., feeder temperature – 160^0 C, detector temperature – 160^0 C, other gases – hydrogen and oxygen.

The obtained results were analyzed statistically and significance of differences for the studied values between the nutritional groups was determined with Duncan`s test.

RESULTS

The results of chemical analyses of feed mixtures (Table 1) indicated that the diets fed in group II and III comprised less crude protein by approximately 10% as compared to group I (control). It also held true for chosen exogenous amino acids in both, growing (PT-1) and finishing (PT-2) period. A protein-xanthophyll (PX) concentrate supplement produced from alfalfa instead of soybean meal had only a slightly raised crude protein and amino acid content in group III as against group II.

The average highest daily gains were recorded for the fatteners from the control group, whereas the lowest for group II (Table 2). A PX additive increased body weight gains in group III up to 762 g in comparison with 721 g in group II throughout the fattening period. Similar upward tendencies were observed at feed conversion ratio as a PX additive improved this index by nearly 6%. Limiting a total crude protein content by 10% as regards the requirements of the Polish feeding norms [15] reduced markedly a nitrogen excretion level (by 7.2-7.4%) in pig faeces and urine. The fatteners were also shown to have lower body nitrogen retention rate, i.e. 36.2 g compared to 37.1 g in the pig growing period and 56.0 g as against 60.6 g in the finishing one, II and I group respectively. However, a nitrogen absorption content as a proportion to N feed intake appeared to be higher (53.2% vs. 51.3%) in the pig growing period and slightly lower in the finishing one (46.9% vs. 47.4%). No significant differences were recorded in the liver, heart or kidney weight as well as pig carcass slaughter evaluation parameters, still a slight downward tendency in meat amount in carcass was noted between group I and II (Table 3). The TBARS indices declined from 1.13 in the control to 0.93 mg/kg muscle in group II. Evaluation of meat quality showed higher shear force value in the longissimus muscle as well as more abundant thermal drip. The fatty acid composition of meat fat demonstrated an increased MUFA content in group II and III (Table 4). A supplement of a protein-xanthophyll (PX) concentrate of alfalfa at amount of 30 g kg^{-1} mixture improved feed protein utilization by 4.4-4.5%, promoted significant ($p \leq 0.05$) growth of loin eye area as well as the weight of liver (1344.7 g in group II and 1517.8 g in group III) and kidneys 154.8 g and 194.6 g, respectively. Besides, a PX additive induced higher concentration of haem pigments and haem iron (Table 3). The fatty acid composition of meat fat determined in the fatteners of group III in comparison with group II exhibited an increased PUFA level, linolenic acid predominantly (Table 4).

DISCUSSION

Lowering a protein ration in fatteners` diet has long been recognized the major research object [4, 9, 16] as that contributes to decreased emission of protein metabolism products to environment in animal faeces and urine [5, 10, 17]. However, then concomitant lower animal growth rate and poor carcass quality are frequently observed [11, 12, 19]. Similar trends were noted in the present study, where a 10% decline of crude protein regarding the pig feeding standards [15] caused body weight daily gains lower by 11% in the growing period and 6,1% in the finishing one as well as higher feed conversion ratio in both periods and reduced carcass meatiness. While, in fatty acid profile the elevated level of monoenic acid sum was established.

Nitrogen balance showed a lower N emission rate to environment at its higher absorption as against the N intake, which is undoubtedly beneficial from the environmental protection standpoint. To minimize negative productive effects related to reduced protein supply to fatteners` diet, there were implemented various feed additives like, organic acids, enzymes, probiotics and plant preparations [5, 6, 21, 23]. Their inclusion to the diet allows to obtain higher animal performance with decreased release of protein metabolism end products, mainly ammonia, to the atmosphere [2, 4, 5]. A protein-xanthophyll (PX) preparation of alfalfa employed in the present research contributed to increased body weight gains in both fattening periods, more efficient feed utilization as well as loin eye area growth. Similar results were reported by Bourdon et al. [3] and Yen [23]. Besides, this dietary supplement induced significantly higher absorption of feed nitrogen. The PX concentrate, apart from a high protein content (56-58%) and its biological value, comprises numerous biologically active substances [3], like saponins with their beneficial properties promoting efficient use of feed protein and reduction of odor emissions from livestock wastes. Saponins obtained from Yucca schidigera [6, 10, 11, 19] have been successfully employed for many decades as their addition at the rate of 80 g per 1 ton of full feed ration markedly suppresses activity of enzymes participating in ammonia generation in a pig house. Some other biologically active compounds from estrogen group are equally competent in metabolism modulation and stimulation of higher N feed use and thus, promote better overall performance. Besides, natural antioxidants (xanthophyll and its derivatives) found in the PX preparation reduced TBARS indices but raised a haem iron content and haem pigments in the longissimus muscle. That gives evidence that PX constitutes a rich source of some well available minerals, especially iron and copper [3]. The effect of biologically active substances contained in the concentrate of alfalfa is visualized by increased liver and kidney weight. As far as fatty acid composition is concerned, beneficial influence of a PX preparation was demonstrated in significant growth of linolenic acid level.

CONCLUSION

The present research revealed that there is a large potential to decrease nitrogen emission to the environment by 10% lowering of dietary crude protein intake along with concomitant reduced animal growth rate and elevated mixture utilization. Inclusion of a protein-xanthophyll (PX) concentrate of alfalfa to the diet is likely to diminish disadvantageous productive parameters arising from reduction of a total crude protein level in relation to the Polish pig feeding norms (1993). At the same time, a PX preparation improves feed nitrogen utilization and reduces noxious odour emissions from a piggery. The components of a protein-xanthophyll concentrate of alfalfa contribute to increased liver and kidney weight.

REFERENCES

[1] AOAC, Official Methods of Analysis. International, 17 Ed., AOAC Inter., Gaithersburg, MD, USA, 2000.

[2] Baker D.H, Advances in amino acids nutrition and metabolism of swine and poultry, in: Kornegay E.T. (Ed.), Nutrient Management of Food Animals to Enhance and Protect the Environment. Lewis Publishers, 1996, pp. 41-53.

[3] Bourdon D., Perez J.M., Henry Y., Et Calmes R. Veleur energetique et azotee d'un concentrate de proteines de luzerne, le „PX_1", et utilisation par le porc en croissance finition. J. Rec., Porc. France,

(1980) 227 – 244.

[4] Colina J. J., Lewis A. J., Miller P. S., Fischer R. L., Dietary manipulation to reduce aerial ammonia concentrations in nursery pig facilities. J. Anim. Sci. (2001) 79: 3096-3103.

[5] Den Brok G., van der Peet-Schwering C., Vrielink M., Urine-pH, ammonia emission, and technical results of grow-finish pigs after addition to the feed of organic acids, specifically benzoic acid. Swine Research Station, Rosmalen,1997.

[6] Ender K., Kuhn G., Nurnberg K., and Jacques K.A., Effect of Yucca schidigera extract on performance, carcass evaluation and skatole content of fattening boars. J. Anim. Sci, (1996) 74, (Suppl. 1): 47.

[7] Hornsey H.C., The colour of cooked cured pork I. Estimation of the nitrioidehaem pigments. J. Food Agric. (1956) 7: 534-540.

[8] Karwowska M, Dolatowski Z. J., Grela E. R., The effect of dietary supplementation with extracted alfalfa meal on oxidation stability of cooked ham oxidation stability of cooked ham. Pol. J. Food Nutr. Sci. (2007) 57: 4(B), 271-274.

[9] Kerr B. J., Nutritional strategies for waste reduction management: Nitrogen, in: Longenecker J. B., Spears J. W. (Eds.) New Horizons in Animal Nutrition and Health, Proc. 11th Ann. Carolina Nutr. Conf., Raleigh, 1995, pp. 47-68.

[10] Kornegay E. T., Harper A. F., Environmental nutrition: Nutrient management strategies to reduce nutrient excretion of swine. Prof. Anim. Sci. (1997) 13: 99-111.

[11] Latimier P., Dourmad J. Y., Corlouer A., Chauvel J., Le Pan J., Gautier M., Lesaicherre D., Effect of three protein feeding strategies, for growing-finishing pigs, on growth performance and nitrogen output in the slurry. J. Rech. Porc. France (1993) 25: 295 - 300.

[12] Lenis N.P., Lower nitrogen excretion in pig husbandry by feeding: current and future possibilities. Neth. J. Agric. Sci. (1989) 37: 61-70.

[13] Lenis N.P., Schutte J.B., Amino acid supply of piglets and grow-finish pigs in relation to nitrogen excretion, in: Jongbloed A.W. Coppoolse J. (Eds.), Manure issues: nutritional solutions for pigs and poultry, Wageningen, 1990, pp. 79-89.

[14] Monge H., Simmins P.H., Weigel J., Reductions of the protein content of diets combined with different methionine:lysine ratios. Effects on nitrogen balance in lean-genotype grow-finish pigs. J. Rech. Porc. France (1998) 29: 293-298.

[15] Normy Żywienia Świń. Wartość pokarmowa pasz, Omnitech Pres, Warszawa, 1993.

[16] Panetta D. M., Powersa W. J., Xinb H., Kerrc B. J., Staldera K. J., Nitrogen excretion and ammonia emissions from pigs fed modified diets. J. Environ. Qual. (2006) 35: 1297-1308.

[17] Reese D., Koelsch R., Altering swine manure by diet modification. NebGuide G99-1390-A, Univ. Nebraska Cooperative Extension, 1999.

[18] Schutte J.B., de Jong J., van Kempen G.J.M., Dietary protein in relation to requirement and pollution in pigs during the body weight range of 20-40 kg, in: Verstegen M.W.A., den Hartog L.A., van Kempen G.J.M., Metz J.H.M. (Eds.), Nitrogen flow in pig production and environmental consequences, Pudoc Scientific Publishers, Wageningen, 1993, pp. 259-263.

[19] Sutton A.L., Kephart K.B, Verstegen M.W.A, Canh T.T., Hobbs P.J., Potential of reduction of odorous compounds in swine manure through diet modification. J. Anim. Sci. (1999) 77: 430-439.

[20] Van der Peet-Schwering C., Verdoes P.N., Voermans M., Ammonia emission 10% reduced with phase feeding. Swine research station, Rosmalen, 1997.

[21] Wenk C., Herbs and botanicals as feed additives in monogastric animals. Asian- Austr. J. Anim. Sci. (2003) 16: 282–289.

[22] Witte V.C., Krause G.F., Bailey M.E., A New extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. J. Food Sci. (1970) 35: 582-585.

[23] Yen J. T., Dehydrated alfalfa meal reduced urinary urea excretion in finishing gilts. J. Anim. Sci. (2004) 82: Suppl. 2: 68.