ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. XXXI (3) SECTIO EE 2013

Institute of Animal Nutrition and Bromatology
University of Life Sciences in Lublin, Akademicka 13, 20-950 Lublin
e-mail: pietrzak.radawiec@wp.pl

KRZYSZTOF PIETRZAK, EUGENIUSZ R. GRELA

The influence of protein-xanthophyll concentrate of alfalfa on growth performance and carcass value of growing-finishing pigs

Wpływ dodatku koncentratu białkowo-ksantofilowego z lucerny
na efekty produkcyjne i wartość rzeźną tusz tuczników

Summary. The protein-xanthophyll concentrate obtained from alfalfa is characterized by a high content of protein and biologically active components. The objective of the present study was to determine the influence of protein-xanthophyll concentrate supplement to the diet on pig growth performance, feed conversion ratio, nutrient digestibility, slaughter traits and carcass value of growing-finishing pigs. The study was carried out on 105 growing – finishing pigs of ♀ PLW ×♂ Neckar breed allocated into three experimental groups: C – control, E1 with dietary supplement of 1.5% alfalfa concentrate and E2 – with 3% dietary addition of alfalfa concentrate. Fatteners were slaughtered at 115 or 145 kg body weight. Group E2 showed a marked improvement in digestibility of crude protein and ether extract during the growing period and crude protein in the finishing period ($p \leq 0.05$). The loin eye area from the fatteners slaughtered at 115 kg of live weight was larger by 2.5 cm^2 and by 3.8 cm^2 ($p \leq 0.05$), respectively in groups E1 and E2 as compared to control, whereas the animals slaughtered at 145 kg BW had a larger loin eye area by 1.5 cm^2 and by 1.8 cm^2 ($p \leq 0.05$). The components of a protein-xanthophyll concentrate of alfalfa contributed to a significant increase of liver weight.

Key words: alfalfa, protein-xanthophyll concentrate, pig, performance, slaughter trait

INTRODUCTION

Alfalfa (*Medicago sativa* L.) provides highly nutritious forage in terms of protein, fiber, vitamins, and minerals for ruminant animals and it is used as a basic component in feeding programs for dairy cattle. Thus, it makes important feed for beef cattle, horses and sheep [Samac *et al*. 2006]. Alfalfa is a good source of protein (yield from 1 ha is three times more than soya), but because of its high content of cellulose, hemicellulose

and lignin, fibres scarcely digestible by monogastrics, dried lucerne in unsuitable for compounds for certain young, high performance pigs [Zanin 1998]. Therefore, in the middle of the last century in France, a method for obtaining protein concentrate from alfalfa leaves was developed primarily to obtain a feed rich in protein, nutrients and vitamins especially for monogastric animals [Gaweł 2012].

Pigs are monogastric animals and many nutrients are transferred from the feed to the muscle and fat tissues, so the quality of feed components and type of feed additives have great effect on animal health and meat quality [Karwowska *et al*. 2012, Pettigrew and Esnaola 2001]. The investigations performed by Grela *et al.* [2008], Karwowska *et al*. [2007] showed that the application of protein-xanthophyll concentrate in animal nutrition allows for better performance parameters, good-quality carcass and pork. Several studies highlighted the purposefulness of alfalfa products inclusion into fatteners diet that results in high productive effects and decreased amount of nitrogen released to environment [Bourdon *et al*. 1980, Grela *et al.* 2010, Yen 2004].

The objective of the present study was to determine the influence of protein-xanthophyll concentrate supplement to the growing-finishing pig diets on growth performance, feed conversion ratio, nutrients digestibility, some slaughter traits and carcass value.

MATERIAL AND METHODS

The study was carried out on 105 growing-finishing pigs of ♀ PLW × ♂ Neckar breed allocated into three experimental groups, 35 fatteners each. In each group, 25 animals were chosen and slaughtered at 115 kg live weight and 10 fatteners at 145 kg live weight. The scheme of experiment is shown in Table 1. Pigs were housed in a group of 5 animals per pen in each group, the pens with concrete floors in a temperature – controlled

Table 1. Scheme of experiment
Tabela 1. Schemat doświadczenia

Specification Wyszczególnienie	Experimental groups Grupy doświadczalne		
	control kontrola (C)	exp. 1/dośw. 1 (E1)	exp. 2/dośw. 2 (E2)
Additive of concentrate (%) Dodatek koncentratu (%)	0.0	1.5	3.0
Pigs fattened up to 115 kg (pcs) Świnie tuczone do 115 kg (szt.)	25	25	25
Pigs fattened up to 145 kg (pcs) Świnie tuczone do 145 kg (szt.)	10	10	10

barn where the animals were given free access to feed and water, and checked daily. The fattening pigs were maintained under the veterinary care. The housing conditions (temperature, relative humidity and cooling) were in conformity with the current welfare standards and the same in all the experimental groups. The feeds were balanced for metaboli-

Table 2. Composition (%) and nutrient value of compound feeds
Tabela 2. Skład (%) i wartość pokarmowa mieszanek

Fattening period/Okres tuczu	Grower (30–70 kg)			Finisher (71–115 kg)		
Component/Składniki	C	E1	E2	C	E1	E2
Barley/Jęczmień	53.0	53.0	53.0	74.2	74.2	74.2
Wheat/Pszenica	20.0	20.0	20.0	10.0	10.0	10.0
Fish meal/Mączka rybna	5.0	5.0	5.0	2.0	2.0	2.0
Soybean meal/Poekstrakcyjna śruta sojowa	16.0	14.5	13.0	8.0	6.5	5.0
Alfalfa concentrate PX Koncentrat z lucerny PX	0.0	1.5	3.0	0.0	1.5	3.0
Soybean oil/Olej sojowy	2.0	2.0	2.0	2.0	2.0	2.0
Limestone/Kreda pastewna	1.2	1.2	1.2	1.2	1.2	1.2
Dicalcium phosphate Fosforan dwuwapniowy	1.0	1.0	1.0	1.0	1.0	1.0
Salt (NaCl)/Sól (NaCl)	0.4	0.4	0.4	0.4	0.4	0.4
Premix min.-vit.[1]/Premiks min.-wit.[1]	1.0	1.0	1.0	1.0	1.0	1.0
Lysine – HCl/Lizyna – HCl	0.38	0.38	0.38	0.19	0.19	0.19
Methionine/Metionina	0.02	0.02	0.02	0.01	0.01	0.01
Dry matter (g/kg)/Sucha masa (g/kg)	893.4	893.4	893.4	892.5	892.5	892.5
Crude protein (g/kg d.m.) Białko ogólne (g/kg s.m.)	173.3	173.2	173.4	151.5	151.6	151.7
Crude fibre (g/kg d.m.) Włókno surowe (g/kg s.m.)	39.6	39.6	39.5	42.3	42.3	42.2
Ether extract (g/kg d.m.) Tłuszcz surowy (g/kg s.m.)	38.4	38.4	38.5	37.3	37.3	37.4
Metabolizable energy[2)] (MJ/kg) Energia metaboliczna[2)] (MJ/kg)	12.81	12.81	12.81	12.62	12.62	12.62

[1]Premix min.-vit. – 5 g Ca ($CaCO_3$)/($Ca(H_2PO_4)$/(CaI_2); 1.3 g P ($Ca(H_2PO_4)$; 100 mg Fe ($Fe(SO_4) \times 7H_2O$); 100 mg Zn (ZnO); 23 mg Cu ($CuSO_4 \times 5H_2O$); 1.2 mg I (CaI_2); 0.3 mg Se (Na_2SeO_3); 8.000 IU vitamin A; 1.000 IU vitamin D_3; 60 IU vitamin E; 0.60 mg vitamin K; 4 mg riboflavin; 22 mg niacin; 15 mg pantothenic acid; 0.02 mg vitamin B_{12}; 750 mg choline.
[2]Metabolizable energy according to the equation of Kirchgessner i Roth [1983].
[1]Premiks min.-wit. – 5 g Ca ($CaCO_3$)/($Ca(H_2PO_4)$/(CaI_2); 1,3 g P ($Ca(H_2PO_4)$; 100 mg Fe ($Fe(SO_4) \times 7H_2O$); 100 mg Zn (ZnO); 23 mg Cu ($CuSO_4 \times 5H_2O$); 1,2 mg I (CaI_2); 0,3 mg Se (Na_2SeO_3); 8,000 IU witamina A; 1,000 IU witamina D_3; 60 IU witamina E; 0.60 mg witamina K; 4 mg ryboflawina; 22 mg niacyna; 15 mg kwas pantotenowy; 0,02 mg witamina B_{12}; 750 mg cholina.
[2]Energia metaboliczna wg równania Kirchgessnera i Rotha [1983].

zable energy, protein, amino acids, minerals and vitamins [Grela et al. 2009]. Pigs were fed two types of mixtures, according to the fattening period (Tab. 2). During the experiment pigs were weighed individually at the start of the trial, at the end of the growing period (about 70 kg BW), at the end of the finishing period (about 115 kg BW) and finally, at the end of the finishing plus period (145 kg BW). Feed intake was recorded in individual pens and fattening periods, digestibility of nutrients was measured in three periods of fattening: growing, finishing and finishing plus. The balance examinations were conducted in the metabolism cages, where four growers from a group were placed (40–45, 90–95 kg and 140–145 kg).

The chemical composition was assayed in the samples of feed and feces according to AOAC procedures [2000]. In the right carcasses, after their cooling down, the linear measurements were performed and then a partial dissection in compliance with

SKURzTCh [Różycki 1996]. Besides, the liver and heart were weighed. The results were subjected to analysis of variance (ANOVA) to provide mean values for the groups and standard error of the mean, while significance of differences for the mean values of the studied traits was determined with Duncan's test using Statistica package.

RESULTS

Nutrient digestibility coefficients are presented in Table 3. Addition of 3% protein-xanthophyll concentrate of alfalfa has increased ($p \leq 0.05$) digestibility of crude protein in growing and finishing period in group E-2 as compared to control. Only for ether extract, higher ($p \leq 0.05$) digestibility coefficient was recorded in group E1 and E2 in the grower period. And contrary to that, no significant differences were observed in changes of the other nutrient digestibility in all experimental groups.

Table 3. Nutrient digestibility coefficients (%) of pigs
Tabela 3. Współczynniki strawności składników pokarmowych (%) świń

Trait Cecha	C	E1	E2	SEM
Growing period (40–45 kg) Okres grower (40–45 kg)				
Crude protein/Białko ogólne	83.71^{a}	85.01^{ab}	85.89^{b}	0.51
Crude fibre/Włókno surowe	32.44	32.81	32.35	0.23
Ether extract/Tłuszcz surowy	68.24^{a}	69.33^{b}	69.42^{b}	0.38
Nitrogen-free extraction Bezazotowe wyciągowe	89.41	89.82	90.56	0.29
Finishing period (90–95 kg) Okres finiszer (90–95 kg)				
Crude protein/Białko ogólne	87.59^{a}	88.24^{ab}	88.85^{b}	0.42
Crude fibre/Włókno surowe	52.47	52.81	52.11	0.65
Ether extract/Tłuszcz surowy	80.23	80.68	81.21	0.32
Nitrogen-free extraction Bezazotowe wyciągowe	92.41	93.02	92.98	0.36
Finishing plus period (140–145 kg) Okres finiszer plus (140–145 kg)				
Crude protein/Białko ogólne	86.33	87.02	87.15	0.39
Crude fibre/Włókno surowe	59.31	59.24	59.18	0.36
Ether extract/Tłuszcz surowy	82.34	82.81	82.62	0.32
Nitrogen-free extraction Bezazotowe wyciągowe	93.11	93.22	93.34	0.36

$^{a, b}$values in the same rows denoted with different letters differ significantly ($p \leq 0.05$).
$^{a, b}$wartości w wierszu oznaczone różnymi literami różnią się istotnie ($p \leq 0,05$).

The pigs under study ranged in body weight at slaughter from 115.4 kg up to 116.1 kg (Tab. 4). The effect of dietary supplementation with protein-xanthophyll concentrate of alfalfa on average daily gains was noted. It was also found that better feed

conversion ratio and lower backfat thickness were obtained by the animals from the experimental groups but the differences between the groups C, E1 and E2 were not statistically significant. The carcasses of animals fed the mixture without protein-xanthophyll concentrate additive (group C) had the smallest loin eye area. In group E1 and E2, the loin eye area was larger by 2.5 cm^2 and by 3.8 cm^2, respectively ($p \leq 0.05$). No significant differences were recorded in the heart weight, but importantly, the animals receiving concentrate from alfalfa showed higher (by 6.9% in group E1 and 10.6% in group E2) liver weight as against control.

Table 4. Growth performance of fatteners slaughtered at 115 kg BW
Tabela 4. Efekty produkcyjne tuczników ubijanych przy 115 kg m.c.

Cecha/Trait	C	E1	E2	SEM
Initial body weight (kg) Masa początkowa (kg)	30.4	30.5	30.6	0.63
Slaughter body weight (kg) Masa przy uboju (kg)	115.4	116.1	115.8	1.32
Average daily gains (g) Średnie przyrosty dobowe (g)	894	930	916	31.5
Daily feed intake (kg) Dzienne pobranie paszy (kg)	2.34	2.37	2.38	0.22
Feed conversion ratio (kg/kg) Wykorzystanie paszy (kg/kg)	2.62	2.55	2.60	0.28
Cold dressing yield (%) Wydajność rzeźna (%)	82.4	81.9	81.7	1.63
Loin eye area (cm^2) Powierzchnia oka polędwicy (cm^2)	45.6^a	48.1^b	49.4^b	0.83
Average backfat thickness (mm) Średnia grubość słoniny (mm)	22.8	21.2	21.4	0.09
Weight of heart (g) Masa serca (g)	338	347	352	2.18
Weight of liver (g) Masa wątroby (g)	1444^a	1545^b	1597^b	10.3

$^{a, b}$values in the same rows denoted with different letters differ significantly ($p \leq 0.05$).
$^{a, b}$wartości w wierszu oznaczone różnymi literami różnią się istotnie ($p \leq 0,05$).

Growth performance and some carcass slaughter evaluation parameters of heavy fatteners are shown in Table 5. In this period of fattening, the pigs from the experimental groups had higher daily gains (insignificant differences). The feed conversion ratio of fattening pigs with dietary inclusion of alfalfa meal was lower in comparison to the animals fed without protein-xanthophyll concentrate supplement ($p \leq 0.05$), which is a positive effect of this additive. In group E1 and E2, the loin eye area was larger by 1.5 cm^2 and by 1.8 cm^2, respectively ($p \leq 0.05$) as compared to control. Although the loin eye area was larger in the experimental groups, no statistically significant differences in meatiness between control and experimental carcass of pigs were found. In group E1 and E2, the liver weight was greater by 81 g and 150 g, respectively ($p \leq 0.05$). The weight of heart in all groups was similar.

Table 5. Growth performance of fatteners slaughtered at 140–145 kg BW
Tabela 5. Efekty produkcyjne tuczników ubijanych przy 140–145 kg m.c.

Trait Cecha	C	E1	E2	SEM
Initial body weight (kg) Masa początkowa (kg)	115.8	115.9	115.6	1.31
Slaughter body weight (kg) Masa przy uboju (kg)	141.5	142.9	143.4	1.39
Average daily gains (g) Średnie przyrosty dobowe (g)	887	905	901	21.2
Daily feed intake (kg) Dzienne pobranie paszy (kg)	2.87	2.79	2.78	0.22
Feed conversion ratio (kg/kg) Wykorzystanie paszy (kg/kg)	3.24[a]	3.08[b]	3.09[b]	0.13
Cold dressing yield (%) Wydajność rzeźna (%)	85.4	84.9	84.7	0.73
Loin eye area (cm^2) Powierzchnia oka polędwicy (cm^2)	48.6[a]	50.1[b]	50.4[b]	0.23
Average backfat thickness (mm) Średnia grubość słoniny (mm)	29.8	28.2	28.4	0.11
Meatiness of carcass (%) Mięsność tuszy (%)	54.9	55.8	56.1	0.18
Weight of heart (g) Masa serca (g)	458	461	459	2.35
Weight of liver (g) Masa wątroby (g)	1844[a]	1925[b]	1994[b]	53.4

[a, b]values in the same rows denoted with different letters differ significantly ($p \leq 0.05$).
[a, b]wartości w wierszu oznaczone różnymi literami różnią się istotnie ($p \leq 0,05$).

DISCUSSION

The results of our studies are consistent with those obtained by the other authors, i.e. dietary supplementation with protein-xanthophyll concentrate of alfalfa increase some nutrients digestibility. Similar effects observed with the same level of alfalfa preparation were reported by Grela [2008], especially for crude protein and ether extract.

A protein-xanthophyll concentrate of alfalfa employed in the present research contributed to increased body weight gains in growing, finishing and finishing plus periods, more efficient feed utilization as well as loin eye area growth. Similar research findings were presented by Grela *et al.* [2008], Karwowska *et al*. [2007] and Yen [2004]. The alfalfa preparation includes a lot of phytochemical substances, e.g. carotene, chlorophyll, coumarin, betasitosterol, fumaric acid, isoflavones, alkaloids, saponins, cryptoxanthin, daidzein, genistein, limonene, lutein, zeaxanthin, phytates and L-canavanine [Grela and Kowalczuk-Vasilev 2010, Stochmal *et al.* 2001]. Some researchers showed that the introduction of alfalfa concentrate to the diet of pigs increase the share of red meat and decrease the value of the total change in meat colour [Karwowska 2008]. Similarly,

Dolatowski [2008] obtained better quality meat and products from turkeys and pigs after applying 1.5% protein xanthophyll concentrate from alfalfa compared to the control groups.

The significant growth of liver weight, as found in group E1 and E2 fatteners, can be attributed to the biologically active alfalfa components. A similar increase in liver weight (by 12,9%) in the fatteners receiving supplementary concentrate of alfalfa included into crude protein-reduced diets was highlighted by Grela *et al.* [2008].

CONCLUSION

The results obtained in the study demonstrate that addition of protein-xanthophyll concentrate of alfalfa to pig diets (30 g kg^{-1} feed) is recommended to fattening. Dietary inclusion of the preparation has significantly improved major nutrients digestibility. Diet supplementation with protein-xanthophyll concentrate of alfalfa can potentially shorten the fattening time of pigs. Besides, it was shown that larger loin eye area was obtained by the animals from the experimental groups. The components of a protein-xanthophyll concentrate of alfalfa have contributed to increased liver weight.

REFERENCES

AOAC, 2000. Official methods of analysis of the association of official chemists. 16th ed., Arlington, Virginia, USA.

Bourdon D., Perez J.M., Henry Y., 1980. Veleur energetique et azotee d'un concentrate de proteines de luzerne, le „PX1", et utilisation par le porc en croissance finition. Journées Rech. Porcine en France 12, 227–244.

Dolatowski Z.J., 2008. Jakość mięsa i produktów z indyków i świń żywionych paszą z dodatkiem koncentratu białkowo-ksantofilowego (PX) z lucerny. In: Grela E.R. (ed.), Lucerna w żywieniu ludzi i zwierząt. 3rd International Conference „Feed and Food Additives", Dzierdziówka–Lublin, 93–105.

Gaweł E., 2012. Chemical composition of lucerne leaf extract (EFL) and its applications as a phytobiotic in human nutrition. Acta Sci. Pol., Technologia Alimentaria 11 (3), 303–310.

Grela E.R., Kusior G., Drabik A., 2010. Wpływ dodatku koncentratu (PX) z lucerny w tuczu świń na emisje gazowych zanieczyszczeń powietrza. In: E.R. Grela (ed.), Lucerna w żywieniu ludzi i zwierząt. 4th International Conference „Feed and Food Additives", Lublin–Sandomierz, 178–179.

Grela E.R., 2008. Wartość pokarmowa lucerny i efektywność koncentratu PX w żywieniu zwierząt. In: E.R. Grela (ed.), Lucerna w żywieniu ludzi i zwierząt. 3rd International Conference „Feed and Food Additives", Dzierdziówka–Lublin, 77–91.

Grela E.R., Kowalczuk-Vasilev E., 2010. Skład chemiczny, wartość pokarmowa i zastosowanie produktów z lucerny w żywieniu ludzi i zwierząt. In: E.R. Grela (ed.), Lucerna w żywieniu ludzi i zwierząt. 4th International Conference „Feed and Food Additives", Lublin–Sandomierz, 13–25.

Grela E.R., Pastuszak J., Bloch U., 2009. Poradnik nowoczesnego żywienia świń. Zalecenia dla praktyki. SRRiL „Progress", Lublin.

Grela E.R., Semeniuk W., Florek M., 2008. Effects of protein-xanthophylls (PX) concentrate of alfalfa additive to crude protein-reduced diets on nitrogen excretion, growth performance and meat quality of pigs. J. Central Eur. Agric. 9, 4: 669–676.

Karwowska M., 2008. Effect of applying alfalfa extract to the diet of pigs on meat colour. Żyw. Nauka Technol. Jakość 5 (60), 282–288

Karwowska M., Dolatowski Z.J., Grela E.R., 2007. 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. 57, 4(B), 271–274.

Karwowska M., Dolatowski Z. J., Grela E.R., 2012. Influence of dietary supplementation with protein-xanthopylls (PX) concentrate of alfalfa. Fleischwirt. Int. 27, 1, 88–91.

Kirchgessner M., Roth F.X., 1983. Schätzgleichungen zur Ermittlung des energetischen Futterwertes von Mischfuttermitteln für Schweine. J. Anim. Physiol. Anim. Nutr. 50, 270–275.

Pettigrew J.E., Esnaola M.A., 2001. Swine nutrition and pork quality: A review. J. Anim. Sci. 79, E316–E342.

Różycki M., 1996. Zasady postępowania przy ocenie świń w stacjach kontroli użytkowości rzeźnej trzody chlewnej. Stan hodowli i wyniki oceny świń. Rocz. Inst. Zoot. 14, 69–82.

Samac D.A., Jung H.G., Lamb J.F.S., 2006. Development of alfalfa (Medicago sativa L.) as a feedstock for production of ethanol and other bioproducts. In: S. Minteer (ed.), Alcoholic fuels. CRC, Boca Ratan, 79–98.

Stochmal A., Piacente S., Piyya C., De Riccardis., Leity R., Oleszek W. 2001. Alfalfa (*Medicago sativa* L.) flavonoids.1. Apigenin and luteolin glycosides from aerial parts. J. Agric. Food Chem. 49 (2), 753–758.

Yen J., 2004. Dehydrated alfalfa meal reduced urinary urea excretion in finishing gilts. J. Anim.Sci. 82, Suppl. 2, 68.

Zanin V., 1998. A New nutritional idea for man: Lucerne leaf concentrate. Association for the Promotion of Leaf Concentrate in Nutrition. Paris.

Streszczenie. Koncentrat białkowo-ksantofilowy jest otrzymywany z lucerny, charakteryzuje się dużą zawartością białka i składników biologicznie czynnych. Celem badań było określenie wpływu koncentratu białkowo-ksantofilowego na wyniki produkcyjne tuczników, strawność składników pokarmowych, wydajność rzeźną oraz jakość tuszy. Doświadczenie przeprowadzono na 105 tucznikach ♀ wbp × ♂ Neckar, podzielonych na trzy grupy: C – kontrolna, E1 – doświadczalna 1 otrzymująca dodatek 1,5% koncentratu z lucerny i E2 – doświadczalna 2 otrzymująca dodatek 3% koncentratu z lucerny. Tuczniki ubijano przy 115 i 145 kg masy ciała. W grupie E2 odnotowano wyraźną poprawę strawności białka i tłuszczu surowego w okresie grower oraz samego białka surowego w okresie finiszer ($p \leq 0,05$). Powierzchnia oka polędwicy tuczników ubijanych przy 115 kg masy ciała z grup doświadczalnych E1 i E2 była większa niż w grupie kontrolnej odpowiednio o 2,5 cm^2 i 3,8 cm^2 ($p \leq 0,05$), natomiast tuczników ubijanych przy 145 kg masy ciała o 1,5 cm^2 i 1,8 cm^2 ($p \leq 0,05$). Składniki koncentratu białkowo-ksantofilowego z lucerny istotnie przyczyniają się do zwiększenia masy wątroby.

Słowa kluczowe: świnie, lucerna, koncentrat białkowo-ksantofilowy, cechy tuczne, cechy rzeźne