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NUTRIENT DIGESTIBILITY AND NITROGEN BALANCE IN GROWING-FINISHING PIGS FED DIETS CONTAINING BLUE LUPINE (*Lupinus angustifolius*) SEEDS

WPLYW ŁUBINU WĄSKOLISTNEGO W MIESZANKACH DLA TUCZNIKÓW NA STRAWNOŚĆ SKŁADNIKÓW POKARMOWYCH I BILANS AZOTU

Abstract: The objective of this study was to determine the effect of total substitution of blue lupine seeds (cv. Wersal, Baron and Zeus) for soybean meal in diets for growing-finishing pigs on nutrient digestibility, nitrogen retention and nitrogen utilization. Balance and digestibility trials were conducted on 24 pigs with body weight of approximately 60 kg, divided into four groups. In the control, diet the main source of protein was soybean meal (15 %), which was replaced with blue lupine seeds cv. Wersal (29 %), Baron (26 %) or Zeus (30 %) in experimental diets. The cereal component was barley grain, and the diets were supplemented with synthetic amino acids, minerals and vitamins, so as to meet the nutrient requirements of animals.

Total protein digestibility was high and comparable in all groups (75.7–77.5 %). Significant differences were noted with respect to the digestibility of crude fat and crude fiber, which was found to be lower in pigs fed a diet containing blue lupine seeds cv. Baron.

Nitrogen intake was at a similar level in all groups (65.8–67.4 g), while the highest nitrogen retention was observed in the control group (24.6 g). In experimental groups nitrogen retention ranged from 20.3 to 21.7 g, due to higher fecal and urinary nitrogen excretion. Nitrogen utilization (retention/intake, retention/digestion) was slightly higher in the control group, at 36.6 and 47.7 %, compared with 30.2–32.3 % and 41.1–44.3 % respectively in experimental groups. The results of the study indicate that blue lupine seeds used as the main source of protein in diets for growing-finishing pigs may affect nutrient digestibility and fecal and urinary nitrogen retention.

Keywords: blue lupine, digestibility, nitrogen balance, growing-finishing pigs

Nitrogen excretion is dependent on ration balancing for energy and protein, to meet the animal's requirements. Nutrient utilization can be improved by selecting appropriate feed components which increase the digestibility of energy and protein, and their

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utilization for production purposes. In pig fattening, the efforts to minimize nitrogen excretion may be hindered by diet formulation with an excess of protein, and by an insufficient supply of essential amino acids [1]. Typical diets for pigs often contain only lysine or sulfur amino acids, whereas other limiting amino acids are disregarded [2, 3].

The effect of blue lupine seeds as the main source of protein and a substitute for soybean meal in diets for growing-finishing pigs, supplemented with synthetic amino acids, was determined based on nutrient digestibility. Nitrogen balance, including the retention and utilization of this nutrient, was also analyzed.

Materials and methods

The experimental materials comprised seeds of three blue lupine cultivars, Wersal, Baron and Zeus, used as the main source of protein in diets for growing-finishing pigs (Table 1). In the control group (I) the major protein component was soybean meal (15 %), which was replaced with blue lupine seeds in experimental diets, as follows: group II – cv. Wersal (29 %), group III – cv. Baron (26 %), group IV – cv. Zeus (30 %). The cereal component was barley grain. All diets were supplemented with synthetic amino acids (lysine, methionine, threonine and tryptophan), minerals and vitamins, so as to meet the nutrient requirements of animals.

Table 1

Composition [%] and nutritional value of diets

Components	Group			
	Control I	Wersal II	Baron III	Zeus IV
Barley	82.05	67.88	70.87	66.90
Soybean meal	15	—	—	—
Blue lupine	—	29	26	30
Feed additives*	2.5	2.5	2.5	2.5
L-lysine	0.32	0.4	0.4	0.35
DL-methionine	0.08	0.15	0.15	0.17
L-threonine	0.05	0.06	0.06	0.05
L-tryptophan	—	0.02	0.02	0.03
1 kg mixed feed				
ME [MJ]	13.04	13.03	12.40	12.79
Crude protein [g]	161.3	162.5	161.8	162.1
Crude fiber [g]	38.0	74.8	69.9	75.9
Oligosaccharides [g]	—	21.3	18.1	20.0
Alkaloids [g]	—	0.16	0.09	0.12

* Limestone, dicalcium phosphate, NaCl, mineral-vitamin premix.

The diets were fed to 24 growing-finishing pigs with body weight of approximately 60 kg. The animals were kept and fed individually. Nutrient digestibility and nitrogen balance were determined by standard methods.

The results were verified statistically by a one-factor analysis of variance (ANOVA) and Duncan's multiple range test, using STATISTICA 7.0 software.

Results and discussion

The blue lupine cultivars used in the experiment differed with regard to their chemical composition (Table 2). The protein content of seeds was as follows: cv. Wersal – 316.7 g/kg, cv. Zeus – 319.0 g/kg, cv. Baron – 333.2 g/kg. Blue lupine seeds contained small amounts of crude fat (48.7–54.6 g), slightly different levels of N-free extractives (409.3–428.3 g), and comparable concentrations of crude fiber.

Table 2

Chemical composition of blue lupine seeds [g/kg d.m.]

Specification	Blue lupine cultivars		
	Wersal	Baron	Zeus
Total protein	316.7	333.2	319.0
Crude fat	49.8	48.7	54.6
N-free extractives	428.3	409.3	419.2
Crude fiber	164.8	167.5	167.0
NDF	265.4	271.6	249.7
ADF	224.5	221.0	223.0
ADL	12.2	11.5	13.5
Hemicelluloses	40.9	50.6	26.7
Cellulose	212.3	209.5	209.5
Alkaloids	0.56	0.36	0.41
Oligosaccharides	73.6	69.7	63.2

Significant differences were noted with respect to the content of neutral detergent fiber and hemicelluloses which were most abundant in cv. Baron. The control diet with soybean meal and experimental diets containing blue lupine seeds were formulated as iso-protein diets, with protein concentrations ranging from 161.3 to 162.5 g (Table 1). Experimental diets with lupine seeds contained slightly different amounts of oligosaccharides (18.1–23.0 g/kg). The alkaloid content of experimental diets II, II and IV (0.09, 0.12 and 0.16 g/kg, respectively) depended on alkaloid concentrations in the seeds of particular lupine cultivars.

Table 3 presents the digestibility of nutrients from the control and experimental diets. The replacement of soybean meal with seeds of three blue lupine cultivars resulted in high total protein digestibility (75.7–77.5 %), which was comparable in all groups. These values are consistent with those reported by Fernandez and Batterham [4], and somewhat lower than those obtained by Salgado et al [5] for diets with a high content of lupine seeds. The findings of Froidmont et al [6] also confirm the need to supplement diets for pigs with all essential amino acids.

The use of blue lupine seeds as a substitute for soybean meal in diets for pigs allowed to achieve high total protein digestibility, but it decreased the digestibility of other nutrients. Among the three tested lupine cultivars, the lowest nutrient digestibility coefficients were noted for cv. Baron whose seeds had higher concentrations of hemicelluloses and NDF, compared with the seeds of the other two cultivars.

Table 3

Nutrient digestibility and nitrogen balance

Specification	Group				SEM
	Control I	Wersal II	Baron III	Zeus IV	
Digestibility coefficient [%]					
Total protein	77.5	76.8	75.7	76.5	0.377
Crude fat	46.0 ^{AC}	41.9 ^A	29.6 ^{Bb}	37.3 ^{ADa}	1.624
Crude fiber	45.1 ^A	45.0 ^A	35.4 ^{Bb}	43.5 ^a	1.304
N-free extractives	90.3 ^A	89.7 ^a	88.3 ^{Bb}	88.8 ^B	0.224
Daily nitrogen balance					
N intake [g]	67.1	65.8	67.4	67.4	0.522
N excreted in feces [g]	15.6	16.4	18.3	18.2	0.470
N excreted in urine [g]	26.9	29.1	27.3	28.9	0.728
N digestion [g]	51.5	49.4	49.0	49.2	0.580
N retention [g]	24.6	20.3	21.7	20.4	0.876
Retention/digestion [%]	47.7	41.1	44.3	41.4	1.667
Retention/intake [%]	36.6	30.8	32.3	30.2	1.233

a, b, c, d – $p < 0.05$; A, B, C, D – $p < 0.01$

Nitrogen balance parameters (Table 3) were negatively affected by the addition of lupine seeds to diets, despite their supplementation with amino acids. Nitrogen intake was at a similar level in all groups (65.8–67.4 g), while the highest nitrogen retention was observed in the control group (24.6 g). In experimental groups II, III and IV nitrogen retention was 20.3, 21.7 g and 20.4 g respectively, due to higher fecal and urinary nitrogen excretion Rahman et al [7] and Froidmont et al [6] also pointed to the possibility of increased urinary nitrogen excretion in pigs fed diets containing lupine seeds. Nitrogen utilization in relation to nitrogen intake and digestion was higher in the control group, at 36.6 and 47.7 %, compared with 30.2–32.3 % and 41.1–44.3 % respectively in experimental groups. In the groups receiving diets with lupine seeds, the best nitrogen utilization was noted for cv. Baron, which could result from the lowest concentrations of oligosaccharides in the seeds of this cultivar (oligosaccharides are known to limit nitrogen utilization). The nitrogen balance parameters obtained in this study for growing-finishing pigs fed diets with blue lupine seeds are similar to those reported by Chachulowa et al [8] and slightly worse than those presented by Salgado et al [5].

Conclusions

The use of blue lupine seeds (cv. Wersal – 29 %, cv. Baron – 26 %, cv. Zeus – 30 %) as a substitute for soybean meal in diets for pigs allowed to achieve high total protein digestibility, but it decreased the digestibility of other nutrients. Among the three tested lupine cultivars, the lowest nutrient digestibility coefficients were noted for cv. Baron

whose seeds had higher concentrations of hemicelluloses and NDF, compared with the seeds of the other two cultivars.

The supplementation of lupine-containing diets with amino acids did not enable to reduce nitrogen excretion to the environment. Despite the high digestibility of protein from experimental diets, comparable with that of protein in a cereal-soybean diet, higher amounts of nitrogen were excreted in feces and urine following the intake of lupine-based diets.

In view of a reduction in atmospheric nitrogen emissions, lupine seeds should not be substituted for soybean meal in diets for growing-finishing pigs, even if these diets are well balanced with respect to the proportions of essential amino acids.

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WPLYW LUBINU WĄSKOLISTNEGO W MIESZANKACH DLA TUCZNIKÓW NA STRAWNOŚĆ SKŁADNIKÓW POKARMOWYCH I BILANS AZOTU

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Abstrakt: Celem badań było określenie w jakim stopniu całkowita substytucja poekstrakcyjnej śruty sojowej nasionami łubinu wąskolistnego odmiany Wersal, Baron lub Zeus różnicuje strawność składników pokarmowych i retencję azotu oraz jego wykorzystanie u tuczników. Badania bilansowo-strawnościowe przeprowadzono na 24 tucznikach o masie ciała około 60 kg podzielonych na 4 grupy. W mieszance grupy kontrolnej podstawowym komponentem białkowym była śruta poekstrakcyjna sojowa (15 %), którą w dietach doświadczalnych zastąpiono nasionami łubinu wąskolistnego Wersal (29 %), Baron (26 %) lub Zeus (30 %).

Komponentem zbożowym było ziarno jęczmienia, oprócz którego zgodnie z zapotrzebowaniem zwierząt, zastosowano aminokwasy syntetyczne i dodatki mineralno-witaminowe.

Strawność białka ogólnego była duża i zbliżona u zwierząt wszystkich grup (75.7–77.5 %). Znaczne różnice dotyczyły strawności tłuszczu surowego i włókna surowego, którą zmniejszyły zastosowane w mieszance nasiona odmiany Baron.

Przy zbliżonej ilości azotu pobranego (65.8–67.4 g) największa jego retencja wystąpiła w grupie kontrolnej (24.6g), w grupach doświadczalnych kształtowała się na poziomie 20.3–21.7 g i była wynikiem większej ilości azotu wydalanego w kale i moczu. Wykorzystanie azotu (retencja/pobrane, retencja/strawiony) nieco korzystniej kształtowało się w grupie kontrolnej i wynosiło 36.6 i 47.7 %, w grupach doświadczalnych odpowiednio 30.2–32.3 % i 41.1–44.3 %. Uzyskane wyniki wskazują, że nasiona łubinu wąskolistnego jako podstawowe źródło białka w mieszankach dla tuczników mogą różnicować strawność składników pokarmowych i wpływać na ilość azotu wydalanego przez tuczniki w kale i moczu.

Słowa kluczowe: łubin wąskolistny, strawność, bilans azotu, tuczniki